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[Special Editorial Correspondence.—Postal Telegraph Cable Co.]

## THE EIGHTH ANNUAL MEETING OF THE PACIFIC COAST GAS ASSOCIATION.

SAN FRANCISCO, July 12, 1900.

Dear JOURNAL: They say occasionally that more attention is given to electric lighting "Pacific Coast way" than is given to gas lighting there; but up to the time of dispatching, which may be dated an early hour of the morning of the 12th inst., let me assure you that gas and its opportunities came in for much consideration yesterday and the day before, during the technical sittings of the eighth annual convention of the Pacific Coast Gas Association. In this I do not mean to be taken as saying that electricity was not doing its best, for the meeting was held in the handsome assembly rooms that are part of the property of the San Francisco Gas and Electric Company. California weather of the best Coast type luckily was our accompaniment, and President Clements looked over a rousing, fine delegation of gas and other men when, at 11 A.M. of Tuesday, he announced that the eighth session of the Pacific Coast Gas Association was underway. Over two score responded to roll call, after which came the report of the Board of Directors, the main feature of the document being the satisfactory recommendation that the names of 20 applicants for membership be added to the permanent roll. The address of President Clements next occupied the attention of the Association. He did not make any startling revelation therein, but he did show through its lines the belief that the trade of the gas man was a fairly good business in which to be engaged. The address having been referred to a special committee for consideration and report, Secretary Grimwood read a long list of communications from those who meant to be present at the meeting, but who, from one cause or another, failed to reach up to their desires. These regretful expressions closed the first morning session. Shortly after 2 P.M. the first afternoon session was commenced. The opening number of the technical programme proper was the paper by Mr. J. B. Crockett, President of the San Francisco Gas and Electric Company, entitled "Some Notes on Larger Types of Gas Engines." Mr. Crockett, who, despite his seeming off-handedness, comes pretty close to knowing what he is talking about all the time, put up a very plain statement of what could be accomplished by the use of gas power well directed, and rather clinched his recital of belief in the remark that the San Francisco Gas and Electric Company had placed an order with the Union Gas Engine Company, of San Francisco, for the construction of a 300 horse power gas engine, to be used for actuating a portion of the electrical generating division of his Company. The discussion on the Crockett paper was all too brief, but the tenor thereof was that when the gas engine business proper was transferred to the domain of engineers, rather than kept in the custody of quacks, the better it would be for power controllers and power users. The report of the Committee on President's Address having been accepted, a right good evidence of the quick life that is in the Pacific Coast Gas Association was recorded in the adoption of a resolution naming Secretary J. B. Grimwood as the Association's official representative at the International Congress of gas men to be held in Paris next September. Good for the Coast gas men.

The second paper read was that by Dr. R. M. Powers, of the San Diego (Cal.) Gas and Electric Light Company, whose theme was "The

Use of Crude Petroleum for Firing Benches." The author put together a series of experiences sufficient to bring out a good discussion, some of which rather went to show that solid fuel could be counted on to still do good work in bench warming. The last paper of the day was the one by Mr. T. R. Parker, whose "Thoughts Suggested by Boiler Explosions" would have been better appreciated by a convention of electrical engineers. Not that his ideas were not worthy of appreciation, but that they in the main appealed rather to Yaryan and his followers than to those who convey fairly stable vapors through pipes or mains.

The second day's proceedings were started at something after 10 A.M. The opening number was the paper by Mr. Alexander C. Humphreys, of New York. In the absence of the author the paper was read by Secretary Grimwood, and after the discussion thereon a special committee ("our own" Ed. C. Jones and the Coast "gas Nestor," F. H. Eichbaum) was named to thank Mr. Humphreys for his paper. Mr. Humphreys is especially qualified to write to the topic of "The Investigation of Gas Processes," perhaps outside of coal gas lines; and it must have pleased the man from Oakland (Mr. John A. Britton) immensely to know that, in a recent dictum of Mr. W. J. Dingee, President of the Oakland Gas, Light and Heat Company, Mr. Humphreys and Mr. Dingee were in complete accord over the total failure of the Hall process in San Francisco and Oakland. The next incident was the lecture, by Mr. A. S. Cooper, the State Mineralogist of California, who, through his assistant, Mr. Charles G. Yale, gave an interesting tabulation of "Some Physical and Chemical Characteristics of California Petroleum." The election for officers was then gone on with, the result reached being the naming of the following:

*President*—John A. Britton, Cal.

*Vice-President*—C. E. Burrows, Walla Walla, Wash.

*Secretary and Treasurer*—J. B. Grimwood, San Francisco.

*Directors*—W. G. Barrett, Thos. Thompson, J. W. Thomas and A L. Rice.

Some of the chosen responded and some did not, the response by Mr. Britton being if anything eclipsed in the response by Mr. Burrows. The afternoon's business of the second day was started with the reading of the paper by Mr. Britton on the "Best Method of Introducing Gas Stoves." There was not a dingy line in his story, and its composition was such as to lead many of the delegates to assist in a lively discussion by relating their experiences over the matter in hand. Then came Mr. L. P. Lowe's illustrative paper on the "Synthesis of Commercial Gases." His work was interestingly done, and his hearers were not slow to frequently show their appreciation of it by their applause. The "Wrinkle Department," by Editor Hollidge, next occupied our attention. His good collection of creases having been worn out, Editor Gregory then entertained the Association with a goodly number of "Experiences." A lot of routine business intervened notable in it being the reading of a letter from Mr. George G. Ramsdell, President of the American Gas Light Association, extending a special invitation to the Coast Association to be on hand at the meeting in Denver next October. Of course the usual votes of thanks were passed to those who contributed in any sense to this most successful meeting; but it would take such votes without number to in any sense compensate for the hospitality shown by the people in charge of the social side of the convention. To day (Thursday, remember) we are to visit Mt. Tamalpais for the discussion of the contents of the Question Box and the consumption of a luncheon, after which, at the special invitation of President-elect Britton, we are to return to San Francisco, there to be given a banquet by the men from Oakland. If it is possible, I will send you some account to-morrow of the things that were done to-day. Meanwhile, I may say that we all very much enjoyed the theater party at the Orpheum vaudeville last night, and the many other measures that the committee provided.—C.

San Francisco, July 13, 1900.

Dear Journal: The trip to Mount Tamalpais was a perfect success. The weather was glorious, and over 100 took part in the ascent. We arrived at the summit at noon, and the Question Box was opened and debated, the debating platform being one of the mountain, open passenger cars. Messrs. Hollidge and Gregory were re-elected to their former posts as editors of the "Wrinkle" and "Experience" departments, respectively. Luncheon, and a good one it was, was followed by music and dancing and recitations, and the trip back to 'Frisco was completed before seven. At nine we were the guests of Mr. Britton, under whose tender care we remained until the candle was burning at both ends. Our host was the toastmaster, and he had an efficient aide in "Ed." C. Jones. The meeting was an excellent one, and we who were on hand are all glad that we came.—C.

## Naphthaline from Retort to Point of Deposition.

[A paper prepared by Mr. William Young, of Peebles, Scotland, for the 37th Annual General Meeting of the Incorporated Gas Institute.]

The reason why naphthaline gives such a large amount of trouble and annoyance during the manufacture and distribution of gas is that, as you are aware, at all ordinary temperatures it passes directly from the state of vapor diffused through the gas to that of a crystalline solid. It does this just in the same way that water vapor diffused through gas or air is deposited as crystalline ice or hoar frost, at all temperatures below the freezing point of water.

The difficulties which arise from the deposition of naphthaline are further accentuated by the naphthaline being deposited in fine, thin laminated or feathery crystals. This form of deposit enables a very small weight of naphthaline to occupy a large space; and further, in consequence of their lightness, when these feathery crystals do not become fixed to the walls of the large mains and vessels, they are liable to be drifted or blown forward in the current of moving gas until they become entangled in the narrower passages of the service pipes.

While these properties of the naphthaline are well known as explaining the nature of naphthaline troubles, it is not so well known and recognized that the same cause—the direct assumption of the crystalline form from the vapor, and *vice versa*—to a very considerable extent accounts for the naphthaline vapor being present in the gas, so as to produce the trouble referred to.

To get a clear conception of how such results are brought about, it is necessary briefly to consider certain conditions which prevail, and some of the physical and chemical forces brought into play during the processes of condensation, purification, storage, and distribution.

One ton of ordinary gas coal, when carbonized at the high temperatures employed in modern gas works, will produce approximately from 10,000 to 11,000 cubic feet of permanent gas, accompanied by from 120 to 130 pounds of condensable hydrocarbon vapors, together with variable quantities of water vapor, ammonia, etc. These products leave the retort and enter the stand pipes accompanied by a considerable quantity of flocculent carbon.

*The Opposing Forces During Condensation.*—The separation and allocation of these products, between the gas and the tars, commence immediately on the products of distillation leaving the retorts. The forces which come into play so as to effect the separation are those of the respective vapor tensions, the mutual solubilities, chemical affinities, etc.

The hydrocarbon vapors are all more or less soluble in the liquids which result from condensation, just as the ammonia is highly soluble in the condensed water vapor. The great bulk of the hydrocarbons produced have so low a vapor tension that they cannot remain in the gas in a state of diffusion, but are precipitated as liquids; and these liquids, carrying down with them the flocculent carbon which accompanies the products of distillation, appear as liquid tars.

These liquid tars, having a large solvent affinity for the other and smaller portions of such hydrocarbon vapors as have higher vapor tensions, tend to take them up in solution and to absorb them out of the gas. But these portions have, on the other hand, a strong tendency to remain in diffusion throughout the bulk of the gas. Just in the same way, ammonia gas (which from its high vapor tension tends to remain diffused through the gas) is nevertheless partially absorbed by the condensed ammonia water.

These opposing forces of solution and diffusion depend for their relative values upon the temperature at the time of contact between the condensed liquids and the gases which hold the vapors in diffusion; for, as the temperature falls, the solubility of the vapors in the condensed liquids increases; while the powers of the vapors to remain in diffusion simultaneously decrease.

These opposing forces also depend for their relative values upon the relative constitutions and proportions of the lower tensioned liquids and the higher tensioned vapors; or, to put this in another way, while the vapors may all be more or less soluble in the condensed liquids, still the vapor of some particular hydrocarbon may be present in such proportion as to be able to saturate the combined liquids. The result of this is that after this saturation has taken place, the force of diffusion is left unaffected by that of solution. Naphthaline, as will be afterwards explained, occupies such a position as this.

The power of condensed water vapor to take up the ammonia and acid gases in solution is subject to the same forces.

*Modifications in Condensation.*—By modifying the process of condensation, the action of these forces upon the gas and products may,

within certain limits, be modified in such a way as to bring about small differences in the allocation of the condensable product between the gas and the liquid tars.

If the 10,000 to 11,000 cubic feet of gas, with the accompanying products obtained from the carbonizing of a ton of coal, be passed through a form of condenser which allows of the whole being cooled to atmospheric temperature while the tars and the gas remain in intimate contact, the liquid tars will exercise their full solvent affinity for the more volatile vapors, and will dissolve the maximum quantities of those vapors that they are capable of absorbing out of the given gas, as against the tendency of these vapors to remain in diffusion. In a similar manner, the condensed water vapor will take up in solution the maximum quantity of ammonia, acid gases, etc., which it is capable of absorbing out of the gas, as against the tendency of these vapors to remain in the gas in question. Under such conditions, the force of solution would reach their practical maximum, and the forces of diffusion their practical minimum. On the whole, the condensed tars and water would leave the terminal of the condenser holding in solution the maximum weight of vapors they were capable of absorbing out of the given gas; and, on the other hand, the gas would hold in diffusion a proportionally less quantity of diffusible vapors. In fact, the result would be a balance between the forces of solution and diffusion, as regards the whole bulk of the gas and condensable products at the temperature of the terminal of the condensers.

If, on the other hand, the gas and condensable products were passed through a condensing arrangement in which the liquid tars and water were fractionally separated and removed from contact with the gas and vapors as the condensing and cooling process progressed, then the major part of the liquid tars and water would be precipitated and removed from contact with the gas and the remaining diffused vapors, at comparatively high temperatures. At these comparatively high temperatures, the solvent affinities of the liquid tars and water for the higher tensioned vapors are comparatively small, and the vapor tensions of the more volatile vapors are comparatively great. Under these conditions, the tars and water passing from the condenser will contain only such quantities of the more volatile vapors as they have been capable of absorbing from the gas at the temperatures at which they were last in contact with the gas; and in the long run the gas will pass from the terminal of the condensers holding in diffusion a proportionately larger quantity of the higher tensioned hydrocarbon vapors, and of ammonia, etc.

If the condensing process were still further modified by employing such a form of condenser that the fractionally condensed and precipitated liquids were made to flow backwards against the forward current of warm gas and vapors, the solvent power of the tars and water would become still further reduced, and the power of the gases to hold the higher tensioned vapors in diffusion would be correspondingly increased. The portions of the tars and the water deposited in the forward and cooler portions of the condensers, on flowing backward and meeting the forward flow of the gases, would become hotter; and their solvent power for any vapors they might have absorbed would be correspondingly reduced. The result of this would be that a portion of the vapors dissolved in the condensate would be revolatilized into the warm gas, to be again carried forward to the cooler portions of the condenser, where their less volatile components would be recondensed; but the more volatile vapors would remain diffused through the gas, and be carried forward by it. Through conducting the condensation in this manner, not only would the gases and accompanying vapors from the coal be subjected to a fractional condensation, but the condensed liquids would be subjected to a partial fractional distillation. The more volatile vapors would be continuously driven forward to the cooler end of the condenser; and as the gas would come last into contact with a more volatile portion of the condensate, isolated from the solvent influence of the denser portions of the condensate, the balance of the forces of solution and diffusion would now be that between the more volatile and feebly solvent liquid deposited in the terminal of the condenser, and the gas left comparatively free to take up and retain in diffusion the more volatile vapors that are present. Such, briefly stated, are the actions of the forces which theory, based upon natural laws, would indicate as those affecting the process of condensation.

*Modifications in Products.*—If these views be sound, it follows that, by modifying the methods of condensation of the gas and the accompanying condensable products, the relative proportions of the more volatile hydrocarbons may be modified in their distribution or allocation between the condensed solvent liquid tars and water on the one hand and the gas on the other, as these respectively leave the condensers. This distribution would, however, be largely dependent upon the composition of the condensable vapors; and at best it could only be stated as one of degree. In practice it would be almost impossible so to conduct the process of condensation as to get the conditions necessary to secure a perfect fractionation, and to prevent the solvent affinity of the liquid tars from dissolving out of the gas some of the hydrocarbon vapors which the gas could otherwise have held permanently in diffusion, at all ordinary temperatures. Neither would it be any more possible to carry on the process of condensation so as to prevent the gas which passes from the terminal of the condenser from holding in diffusion the vapor of hydrocarbons, which it could not hold permanently in diffusion at the temperatures to which it is afterwards liable to be subjected; and these are, under those circumstances, subsequently deposited.

*Distillation of Tars.*—When the 10,000 to 11,000 cubic feet of gas, with the 120 pounds or so of hydrocarbon vapor obtained by the carbonization of a ton of coal, are subjected to condensation in any of the ordinary condensing arrangements, and by existing methods as applied in modern works, there are obtained approximately 120 pounds of liquid tars. These tars hold in mechanical suspension from 25 to 30 pounds of flocculent, sooty carbon, and when subjected to careful fractional distillation, from 2 to 3 pounds of naphtha distill over before crystalline naphthaline makes its appearance. Thereafter the immediately succeeding portions of the distillate are so rich in naphthaline as to be quite solid on cooling, and these portions would choke up the condenser, unless it were kept hot. On the major part of the naphthaline distilling over, the distillate again becomes liquid; and it remains so until anthracene makes it appearance, whereupon the distillate again becomes pasty on cooling.

*Constituents of Tars.*—It is unnecessary for our purpose to go into the analysis of the tars further than to say that it shows that the 2 to 3 pounds of distillate coming over before the naphthaline, and therefore having a higher vapor tension than that substance, are mainly composed of benzole and its higher homologues, with small quantities of other hydrocarbons, and that the hydrocarbons present in the tar and liquid at ordinary temperatures, with vapor tensions similar to that of naphthaline, are very small in quantity. This explains why naphthaline passing over, unaccompanied by solvent liquids, would choke up the condenser of the still unless this were kept sufficiently warm.

The quantity of naphthaline present in the tars from a ton of coal amounts approximately to from 12 to 14 pounds; and in the tars naphthaline is far and away the most abundant individual hydrocarbon present. The quantity in question is more than the liquid hydrocarbons present in the tars could themselves hold in solution; and naphthaline is only prevented from separating out of the tar in a crystalline form by the presence of the sooty carbon and other substances with which it is associated.

*Gas Treated with Dead Oils.*—If the dead oils—that is, the oils which have tensions only equal to, or lower than, that of naphthaline, and from which the benzole homologues and other hydrocarbons, together with the naphthaline, have been removed by fractional distillation and filtration—are brought into contact with the gas as it leaves the terminal of the condenser, these denser oils at once reassert their solvent power for the hydrocarbon vapors that have been left in diffusion, and dissolve them out of the gas. In the same manner ammoniacal water, if denuded of the dissolved ammonia by distillation, and then cooled and again brought into contact with the gas, will reassert its solvent power, and will dissolve out the ammonia diffused through the gas; and just as it is possible, by fractionally applying the denuded ammonia water to the gas, to absorb the last traces of ammonia, so is it possible, by means of the dead oils, to absorb every trace of the volatile hydrocarbon vapors out of the gas. On heating in a still the denser oils that have been thus employed to dissolve the hydrocarbon vapors out of the gas, the solvent power of these denser oils is overcome; and the absorbed hydrocarbons have their vapor tensions raised and distil over. An analysis of the distillate thus obtained shows that the 10,000 to 11,000 cubic feet of gas leaving the condenser hold in diffusion approximately from 20 to 24 pounds of hydrocarbon vapors, which have a constitution identically the same as that of the more volatile portions of the distillate of the tar. The more volatile benzol is present in quantities approximately from 16 to 18 pounds, with from 2 to 6 pounds of the higher homologues of benzol, together with small quantities of other hydrocarbons, including from 0.10 to 0.14 pounds of naphthaline. It may be desirable at this point to explain that the 20 pounds or so of hydrocarbon vapors in the gas is not nearly all that it could take up in diffusion.

*Solvent Power and Diffusion.*—Through ascertaining, by the distillation of the tar, the quantity of the volatile hydrocarbons it holds,

we obtain a measure of the solvent power of the liquid tars—their power to dissolve out of the gas those volatile vapors which would otherwise tend to diffuse through the gas. And through absorption of the diffused vapors out of the gas, by means of the dead oils, we get a measure of the quantity of volatile hydrocarbon vapors that can be held in diffusion through the gases, as against the solvent power of the liquid tars.

*Crystallization of Naphthaline.*—There is one other force that it is necessary to take into consideration—that is, the force of crystallization, so far as it affects the process of condensation. All the hydrocarbons which are present in tars, and which are liquid at ordinary temperature, are soluble, or at least miscible, in each other in all proportions; and remain equally diffused through each other when mixed. With the hydrocarbon naphthaline, the state of matters is very different. It is only soluble in the liquid hydrocarbons in certain definite proportions at given temperatures. Whenever the conditions are such that the naphthaline is present in quantities greater than can be held in solution in the liquids, the excess, by the force of crystallization, is, or tends to become, separated as pure crystalline naphthaline.

Another characteristic of naphthaline is that, on assuming the crystalline state, it loses its solvent affinity for the hydrocarbon vapors present in the gas. Illuminating coal gas can be passed through a mass of crystalline naphthaline without suffering loss in illuminating power. On the other hand, all liquid hydrocarbons, such as have a vapor tension similar to that of naphthaline—even the liquid oils that have been distilled along with the naphthaline and have been separated from it by cold and filtration—when brought into contact with the gas at once absorb the illuminating hydrocarbons.

Although naphthaline in the crystalline form has no solvent affinity for the other hydrocarbon vapors in the gas, yet if naphthaline vapors are present in the gas to supersaturation, any crystals of naphthaline previously deposited form a nucleus on which the naphthaline vapors are preferably deposited, in the solid state; and, on the other hand, any crystals of naphthaline tend to pass directly from the solid state to the state of vapor into a gas not saturated with naphthaline, when such gas is brought into contact with them. Possessed of these facts, we are now in a position better to understand the conditions which obtain in the different methods of condensation.

*Condensation and Distillation Compared.*—The process of condensing the gas and products coming from the retorts is, in a sense, practically the reverse of the process of distillation of the tars. In the process of distillation, the tars are placed in a still and gradually heated. The vapor tensions of the different hydrocarbons are thus successively raised, until they become equal to that of the atmosphere. Those with the higher vapor tensions distil over first, and are followed successively by those of lower vapor tensions, as heat is imparted to raise their tensions successively to that of the atmosphere. The vapors are all successively evaporated in the presence, and from the surface, of the liquid tars remaining in the still.

In the process of condensation, the whole of the condensable hydrocarbons leave the retorts in the form of vapor; and by the withdrawal of the heat from the vapors, their tensions are reduced until they fall below that of the atmosphere. Then they pass into the liquid condition; the vapor with the lowest tension condensing first, followed by those of higher and higher tensions, as more and more heat is withdrawn. In this process, the vapors are all successively condensed from, and in presence of, the vapors which still remain uncondensed.

The only essential difference between these reverse processes is that, in the case of condensation, the condensable hydrocarbon vapors leaving the retort are accompanied by the permanent gas; and, as a consequence, the tension of the gas, or the tendency of the gas to hold the vapors in diffusion, is added to that of the hydrocarbon vapors, for which reason the temperature at which the vapors condense in the presence of the permanent gas is so much lowered that the more volatile vapors which, if pure, would be condensed to the liquid state at ordinary temperatures, are, by the added tension of the gas, held in diffusion.

In the process of distilling the tars, on the other hand, as we have already seen, the benzol and its homologues, together with other hydrocarbons of high vapor tensions, distil over first. Thereafter the crystalline naphthaline makes its appearance in such quantities, and accompanied by so small a quantity of other hydrocarbons that are liquid, that it crystallizes, and would choke up the still condenser unless the temperature were kept high; and, after the bulk of the naphthaline has distilled over, the distillate again becomes liquid till the anthracene appears, when it again becomes pasty on cooling.

*Theoretical and Practical Results.*—Now, seeing that the process of condensation is the reverse of that of distillation, it would naturally follow that in the process of condensation the reverse sequence of conditions should obtain. We might accordingly expect the pasty hydrocarbons to be first precipitated, carrying with them the sooty carbon. Thereafter the comparatively liquid tars, followed by the deposition of crystalline naphthaline; and finally the precipitation of any excess of the more volatile benzol, its homologues, and other hydrocarbons of high tensions beyond the amounts which the permanent gas could hold in diffusion.

Such undoubtedly would be the sequence of precipitations of the vapors out of the gas, provided that conditions could be realized such as would bring about a sufficiently perfect fractional cooling, and the precipitation and continuous removal of the condensate. In practice, however, it is impossible to realize such ideal conditions, either during the distillation of hydrocarbon liquids, or in their condensation. This is because the solvent fluids in the still retain small quantities of hydrocarbon vapors that would distil over were it not for the solvent power of the liquid; and, again, because the more volatile vapors in the still take up in diffusion dense vapors which would otherwise remain liquid. The same considerations affect the process of condensation; but, of course, in a reverse manner. Hence the impossibility of effecting the separation of liquids which have different vapor tensions by a single distillation or condensation. Besides, there is in the condensation of coal gas and its products the further difficulty that, when hot gas holding vapors in diffusion is more or less suddenly cooled, the vapors on passing into the liquid state are liable to do so in an extremely fine state of division. The more quickly the cooling is effected, the finer is this state of division; and if at the same time that the gas is suddenly cooled it is driven forward at a high velocity, these finely divided liquid particles are apt to be carried forward in the current of gas through long distances.

*Attempts to Solve the Problem.*—These facts have been fully recognized, and many different arrangements of condensing plant have been devised in order to overcome the objectionable conditions, such as carrying mains of large area round the walls of the retort house, so that the warm gas might be slowly cooled in the warm house while it traveled slowly, in order to allow the floating condensed liquids to coalesce and precipitate out of the gas, before final cooling in the condenser to the temperature of the atmosphere.

There have been many other arrangements, with some of which the author was connected more than twenty years ago, by which not only were the products slowly fractionally cooled, but the condensed liquid products precipitated out of the gas were themselves made to travel against the current of warm gas and products; and in some cases the liquid tars were even warmed up, not only by the gas, but by heat from other sources, and were thus subjected to a fractional distilling process, as well as to a fractional condensing process.

Such arrangements of condensing plant undoubtedly presented advantages, more particularly where cannel coal was used, or even where common coal was used at lower temperatures than is now the practice, and when naphthaline was not an abundant product. The advantages, however, are questionable, under modern conditions, in which the coal is carbonized at such high temperatures as greatly to alter the constitution of the tars, and to cause naphthaline to be present in such excessive quantities.

*Practical Experiences.*—Some time ago the author was consulted by an eminent gas engineer connected with a large provincial town in England, who had been experiencing grave troubles from naphthaline deposits. He had visited a great many other works, where coal was being used of the same or a similar class to that used in his own works. Some of these works had had troubles like his own; while others were comparatively free from naphthaline difficulties. He observed—and the author was particularly struck with his faculty of observation—that in the works where condensation was carried out on what was universally believed to be the best principle (that of slowly cooling the gas and removing the liquid tars as they were precipitated), it was found that there the troubles from naphthaline were greatest. On the other hand, in those works where the gases and condensable products were suddenly cooled, and no attempt was made to fractionally condense the gas and separate the tars as they were formed, the troubles from naphthaline deposits were least.

*Explanation of the Results.*—Applying the facts and theories which we have been considering to these conditions, the explanation of those results is simple. In the works provided with condensing arrangements for slow fractional cooling of the gas and vapors, and for removal of the liquid tars from contact with the gas as soon as they are precipi

tated, the best practicable conditions are provided for restricting the solvent affinity of the tars, and for allowing the more volatile vapors to be carried forward in the gas. Now what are those vapors? We have seen that the most volatile hydrocarbon vapors present in the gas as it leaves the retort are benzol and its homologues, with small quantities of other hydrocarbons; that the quantity of these accompanying the gas is not nearly sufficient to saturate the large volume of gas; that the hydrocarbon presenting the next highest tension is naphthaline; and that this hydrocarbon is present in very large quantities. It is evident that the naphthaline will be the hydrocarbon carried forward in large quantities to the cooler end of the condenser; and as the quantities of vapors having tensions similar to that of naphthaline are extremely small, the naphthaline will pass directly from the state of vapor into that of a solid, and will be deposited on the walls of the condenser in the crystalline form. That such is the result is fully borne out by practical experience; the choking up of the terminal end of the condenser with crystalline naphthaline being a common experience.

*In the Condenser.*—As the quantity of hydrocarbon vapors which have tensions higher than that of naphthaline is never sufficient to saturate the gas, it is evident that under such conditions the gas coming last into contact with any naphthaline crystals deposited on the walls of the condenser will leave the condenser practically saturated with naphthaline vapors, at the temperature of the terminal of the condenser. This is necessarily so; for in whatever way the temperature may vary, naphthaline crystals will be presented to, and brought into contact with, the gas as it leaves the condenser. Should the temperature be very low, a further quantity of naphthaline will be added to the crystals. Should, on the other hand, the temperature rise, a portion of the previously deposited naphthaline would be sublimed or volatilized with the gas. Had the naphthaline condensed as a liquid, such conditions could not have prevailed, because it would have flowed out of the condenser as it was precipitated, and away to the tar well.

The zone, so to speak, or the portion or region of the condenser in which the naphthaline will be thus deposited and re-volatilized into the gas, will vary with changes of the atmospheric temperature, variations in the makes of gas, etc. As the atmospheric temperature falls, or the make decreases, the zone will retreat towards the inlet end of the condenser; and, *vice versa*, on a rise of temperature, or an increased make of gas, the zone will be driven forward nearer the terminal cold end of the condenser, and might even, under exceptional circumstances, such as sun's rays falling upon the terminal end of the condenser, be driven forward out of the condenser altogether, into the other portions of the plant.

The same conditions which would lead to variations in the position of the zone of naphthaline deposition in the condensers would have a like effect in altering the zone of deposition of the liquid tars; and it is conceivable, indeed very probable, that an advancing zone of depositing liquid tars may be, under certain conditions, driven forward at such a rate as to overtake the advance of the zone of naphthaline. Under such circumstances, the naphthaline, instead of re volatilizing into the gas, would be to a large extent dissolved by the tars, and carried away out of the condenser by them; and there is little doubt that such conditions are being constantly brought about in everyday practice, otherwise the condensers would choke up much more quickly than they do.

Mr. Carpenter has devised an ingenious arrangement for condensing, by which the zone of depositing tars can be made to overlap the naphthaline zone at will, by alternately reversing the current of gas and products, and thus making each terminal of the condenser alternately the inlet and the outlet. During the period of the overlapping of the tar and naphthaline zones, a part, and no doubt the major part, of the naphthaline is dissolved by the liquid tars, and passes away in solution along with these; but a small portion of the naphthaline is sublimed or volatilized and carried forward in the current of gas. A part of this portion might be carried right through the condenser into the scrubber.

In those works which were provided with condensing arrangements, in which the gas was suddenly cooled, the tar vapors would be reduced to the liquid condition, but in such an extremely fine state of division that they would keep floating forward in the current of gas; and long before the major part of them was removed by coalescence, by friction on the walls of the pipes, or by impact on the bends, they would be so reduced in temperature that the bulk of the naphthaline vapors in the gas would be absorbed and dissolved. Then, further, the presence of the remaining more finely divided tars would so interfere with the forces of crystallization as to prevent the naphthaline being deposited in the crystalline form; and consequently the naphthaline would be removed from the condenser along with the tars, instead of being deposited as crystals on the walls of the pipes of the condenser. No doubt the gas would pass from the condenser still polluted with small quantities of tar particles and still containing naphthaline vapors in diffusion; but the tar particles would be removed in the washer and scrubber. The naphthaline left in diffusion through the gas would be smaller in quantity, and not liable to violent fluctuations. Such fluctuations do result, on the other hand, from the conditions presented in the fractional method of condensation. Under that method, we have crystals of naphthaline continuously presented to the gas during considerable changes of temperature at the terminal of the condenser, or at the point of last contact.

There is also no doubt that, under the method of sudden cooling, the conditions of contact between the liquid tar particles and the gas, which resulted in the solution of the naphthaline, would further enable the tars to dissolve out of the gas some of the benzole and other vapors that would otherwise have remained permanently diffused through it. From a series of experiments made many years ago, the quantity of those higher tensioned vapors so absorbed was, however, found to be extremely small; and this absorption did not reduce the illuminating power, under ordinary temperature conditions, to any very appreciable extent. The reason for so small a loss is that, when coal is carbonized at a high temperature, the quantity of those hydrocarbons which have a higher tension than naphthaline falls so very far short of what would be necessary in order to saturate the gas, that the absorption of a very small quantity of these more volatile hydrocarbons is sufficient to establish a balance between the solvent power of the tars and the power of the large volume of gas to hold the rest of the more volatile hydrocarbon vapors in diffusion.

It is unnecessary, for our present purposes, to discuss those two methods of condensation, as applied to the condensation of the gas and products from ordinary gas coals carbonized at high temperatures, further than to say that both theory, founded upon the action of natural laws, and practical experience, would point to a modification of both as being what is desirable—viz., to get the liquid tars precipitated out of the gas, and yet not to remove the tars and gas from contact with one another, but to keep the tars and gas in intimate contact until both are comparatively cold.

*In the Washers and Scrubbers.*—We have seen how the crystalline naphthaline is, under certain conditions, driven forward right through the condenser into the succeeding parts of the manufacturing plant. The washers and scrubbers, the next part of the plant, after passing the exhauster, are seldom covered in; and, being exposed, they are subject to considerable variations of temperature. When the temperature in the washers and scrubbers was low, the naphthaline driven forward into them would be partially deposited upon the surface of the moving liquids. The naphthaline crystals deposited under such conditions would be extremely small; and the small quantity of liquid tars present would be also in part entangled in the washing water. In this way, a part of the naphthaline passing forward out of the condensers would be removed along with the washer water; but, besides that, another part of the naphthaline would be deposited in the form of large crystals in the empty spaces, in the pipe connections and upon solid surfaces. This deposit of crystalline naphthaline would remain there till there was a rise in temperature, say through increased warmth of the atmosphere, or in consequence of the direct action of the sun's rays; and then these deposited crystals of naphthaline would begin to be re-volatilized and carried forward into the purifiers.

*In the Purifiers.*—The purifiers are generally covered in, and, not being exposed, are not subject to such violent changes of temperature from external causes; but they are subject to great changes of temperature from the chemical action which takes place within them. The temperature of the purifying material in that purifier through which the gas enters the series of purifiers is always warmer than the temperature of the atmosphere; its temperature having been raised by the previous chemical action, the absorption of the acid gases from the coal gas. The naphthaline charged gas, upon entering the series of purifiers, will not be reduced but rather raised in temperature; and, therefore, there will be no naphthaline deposited at this point.

The purifying material, when charged into the last purifier of the series, is necessarily of the same temperature as the air. In order to insure that the gas will not pass the purifiers and yet contain traces of impurities, the last purifier is charged sooner than is absolutely necessary; and the gas must pass through it for some time before chemical action begins. The warmer naphthaline charged gas, on coming into contact with this newly charged purifying material, is necessarily reduced in temperature. As a consequence of this, a part of its naphthaline vapor is deposited on the surface of the cold material, as also upon the cold purifier walls, covers, etc. This cooling of the gas, and de-

position of naphthaline, continues until the current of warm gas, and possibly the advance of the zone of purification and chemical action, sufficiently raise the temperature of the purifying material. Thereupon the deposition of the naphthaline stops and the reverse action begins. From this stage, the naphthaline which is present in the gas that enters the purifier passes on; and what was previously deposited during the cool period is now being re-volatilized by the heat of the chemical action taking place within the purifier. A small quantity of the naphthaline may be left upon the surface of the purifying material and removed with it; but the great bulk of the naphthaline leaving the scrubber is more or less subjected to this alternating action.

The result of this alternating action in the purifiers is that, during the cold period, when the purifier has been newly charged, the gas traversing the last purifier of the series will have the naphthaline vapors present in the gas reduced in quantity, and what remains will only have a vapor tension equal to that of the cold purifying material. Therefore, should the gas passing from the purifier during that period be subsequently raised in temperature, if brought in contact with naphthaline, it could, and would, take it up in diffusion, in quantities corresponding to the rise in temperature. On the other hand, during the hot stage, the gas would pass from the purifier more and more highly charged with naphthaline as the temperature rose; and if it was subsequently lowered in temperature, it would deposit naphthaline.

In some correspondence which appeared in the *Journal of Gas Lighting* some years ago, Mr. A. F. Browne furnished conclusive evidence that such was the actual condition which obtained in practical working. Mr. Browne explained that, at the Old Kent Road Gas Works, it had been customary for several years to watch through glass windows the outlet main at the station meter; that thermometers inserted in these mains close to the glass windows showed the average temperatures in that main to be 4° higher than at the inlet to the purifiers; that in these mains naphthaline in the crystalline form was observed to be deposited, and to go on increasing for a time, and that it subsequently diminished, and even disappeared with great rapidity; that this rapid re-volatilization took place immediately on charging the last purifier with fresh material; and that, after a time, naphthaline again began to be deposited, and continued to be so till the purifier was again charged with fresh material. This proved that the gas was alternately under and supersaturated with naphthaline, even at a temperature 4° above that of the gas entering the purifier; and that those alternating conditions of the gas were due to the changes of temperature which took place at the different stages of purification.

It will be noted that, although the naphthaline crystals were alternately deposited and re-volatilized, there was yet no permanent accumulation of naphthaline in the meter outlet main. This showed that a main having a mean temperature above that to which the gas has been previously exposed will not get choked with naphthaline, so long as the alternations of temperature are confined to short periods of time.

*At the Holder.*—The gas leaving the meter passes on to the gasholder, and on its way it has to pass the inlet to the gasholder, which is deeply buried on the outside of the tank; and the gas has then to pass up through the mass of water inside. While thus situated at a depth, the gas is not liable to violent fluctuations of temperature, but for a great part of the year the mean temperature to which the gas is exposed at this stage is below the mean of the fluctuating temperatures to which it has been previously exposed during its condensation and purification. The result, as is well known, is that the gas during that period of the year deposits more naphthaline than is re-volatilized, and the main becomes gradually choked up with the excess, even although the pipe be of considerable diameter.

In this gasholder, during the period of storage, and in the distributing plant above ground, the gas continues to be exposed to rapid changes of temperature, similar to those in the condensing plant. The underground mains, although not subject to such sudden changes, are yet subject to slower changes of temperature, which play an important part in producing troubles from naphthaline deposits.

We have all observed and admired the beautiful crystals of water deposited upon our room windows after a severe night's frost. These crystals are derived from the moisture diffused through the warm air in the room on its coming in contact with the cold panes of glass. The tension of the water vapor being thus rapidly reduced, the moisture passes from the state of vapor to that of a crystalline solid, assuming those beautiful feathery forms we so much admire. If there were a supply of moist air entering the room while the cold air, denuded of its moisture, passed away, the continued supply of moisture-laden air would deposit its vapors upon the surface of the cold existing crystals, thus adding to their beauty and volume. On a rise of temperature, due, let us say, to the fires being lighted, or to the sun's rays striking the windows, the previously deposited moisture will ultimately evaporate into the warm air and pass away in the air currents.

In a gasholder containing gas holding naphthaline and other vapors in diffusion, a very similar set of conditions would prevail. On a frosty night the plates of the gasholder would play the part of the cold windows, only more perfectly so on account of their greater surface and their better conducting power; and if we could only see the inside of these plates after such a night we would find them, like the window panes, coated with a beautiful deposit of crystals. These crystals would, however, not be pure water crystals, but would be associated with crystals of naphthaline, and if the temperature were extremely low even some of the other vapors of those hydrocarbons which have higher tensions than naphthaline would be condensed to the liquid state. These hydrocarbon liquids would, in that case, condense upon the crystals, and would dissolve a portion of the naphthaline, which would flow down with them and collect on the surface of the water in the tank. If the temperature were low, but not below that of the freezing point of water, then the water vapor would pass out of the gas as a liquid and flow down into the tank, while the naphthaline would still, owing to its high melting point, be deposited on the cold plates as a crystalline solid. Then, in the event of a current of naphthaline charged gas passing into the holder the naphthaline vapor which it contains would go to add to the crystals already deposited.

*In the Mains.*—The gas leaving the holder during this low temperature period would, to a large extent, be denuded of naphthaline vapors, and as it would not in all probability be exposed on its further course to any temperature lower than that to which it had been subjected in the holder it would give no trouble during distribution, unless subjected to certain conditions which will be subsequently considered. If, however, after a longer or shorter period of low temperature, the temperature should rise (say) during a bright sunshiny day, the naphthaline and other hydrocarbon vapors previously deposited in the holder would be re-volatilized into the gas, and the gas would pass into the distributing mains more or less highly charged with naphthaline vapor, to an extent dependent upon the temperature at the holder. The gas thus charged with naphthaline would be very liable to give trouble, as whenever its temperature was reduced below that to which it was exposed in the holder it would deposit naphthaline crystals.

Where these crystals would be deposited, and whether they would give trouble or not, would depend upon a number of conditions, but the main factor would be the mean temperature of the buried mains, and the fluctuating atmospheric temperature dependent upon the season of the year. If, in the first place, the mean temperature of the buried mains was below the mean of the fluctuating surface atmospheric temperature at the holder, then the excess of naphthaline vapors carried forward from the holder by the gas during the short periods of high surface temperature would be mainly deposited in the large trunk mains fairly near the works, and would not be so liable to give trouble. On the other hand, during other periods of the year, when the mean temperature of the buried mains was above the mean surface atmospheric temperatures at the holders, the excess would not be deposited in the mains, but would pass on with the gas. Not only would that be the case, but the naphthaline crystals deposited in the mains when the temperature was below the mean of the surface temperature would now be re-volatilized into the gas. The gas thus left loaded with naphthaline, on reaching the comparatively shallow small mains and exposed services, subject, as these are, to fluctuating surface temperatures, but on the whole colder than the mains, would deposit the excess of naphthaline there in fine feathery crystals, and choke them up, thus giving rise to no end of trouble.

The former set of conditions we find after the mean surface temperatures begin to rise during the late spring and early summer, at which period the mean temperature of the earth at the depth of the mains is below the average mean temperature of the atmosphere. The latter conditions prevail in the autumn and early winter, after the summer heat has warmed the earth to the depth of the mains, and when the average mean surface temperature of the atmosphere falls below that of the buried mains. The troubles from naphthaline deposits during the continuance of the latter conditions are accentuated by the great and rapid fluctuations of temperature which frequently take place in the late autumn and early winter. During such periods, the troubles from naphthaline are often excessive.

*General Conclusions.*—There are many minor causes leading to troubles with naphthaline, such as the precipitation of the naphthaline as extremely fine crystals, and the drifting forward of these in the current of gas, etc.; but it would take more time than is at our disposal,

and, besides, it is not necessary for our present purpose further to consider these. Sufficient has been said to show the important part which the crystalline condition of the naphthaline plays in producing the troubles experienced from the presence of naphthaline vapors in the gas, and also to explain what has been regarded as the eccentricity of the behavior of naphthaline, and to show that these apparent eccentricities are in perfect harmony with well known physical laws. The naphthaline which is the source of trouble may not have been produced at the works immediately before it makes itself manifest in the distant distributing plant, but may have been produced at the works weeks or even months before; and it may, during the interval, have been travelling forward by a series of successive crystalline depositions from and evaporations into the gas, till it reaches the place where it is finally deposited and occasions trouble by choking up the branch mains or service pipes.

*The Remedies.*—The question naturally arises, what are the remedies for these troubles? The answer is that they are of two kinds. The first consists in removal of the naphthaline vapor from the gas, or, at least, in removing such a quantity of those vapors as would prevent them from being deposited during the subsequent distribution of the gas.

The second consists in adding to the gas something that will prevent the naphthaline vapors present in the gas from being deposited in the crystalline form. The solution of these problems is to be found in a further application of those forces which we have just been considering.

We remove the ammonia left diffused through the gas beyond what can be absorbed by the water condensed from the gas in the condensers by a further quantity of the same solvent water. That further quantity of water may be a part of the ammoniacal liquor obtained from the condenser after the ammonia has been separated from it by distillation.

In the dense oils, as obtained by the distillation of the condenser tars, and freed from naphthaline, we have an excellent solvent for naphthaline, as well as for the other hydrocarbons diffused through the gas. If, however, the benzol and other high tension vapors obtained from the distillation of the tars are returned to the dense oil, the solvent power of the dense oil for the benzol and other high tensioned vapors present in the gas is balanced, and the solvent power of the oil is thus restricted to dissolving out the naphthaline. It is, therefore, evident that if the dense oil thus prepared was applied to the naphthaline charged gas after the fashion of the prepared ammoniacal liquor or solvent water in the case of the ammonia, the naphthaline vapor could be as perfectly removed from the gas as it was possible to remove the ammonia by water, and that just as the ammonia absorbed from the gas could be separated by the distillation of the water, so also could the naphthaline be similarly separated by the distillation of the dead oil.

The second remedy, or rather preventative, is to evaporate into the naphthaline charged gas such a quantity of liquid hydrocarbon vapors having vapor tensions approximately the same as that of naphthaline, that when the temperature of the gas falls so low as to cause the vapor of the naphthaline to be precipitated, there will simultaneously be condensed such a quantity of the vapors of these liquid hydrocarbons as will take up the precipitated naphthaline in solution.

The hydrocarbons for both objects may be obtained from any convenient source. A ready means of obtaining a supply of hydrocarbon liquid for either or both purposes, where other sources of supply are not available, is to carbonize a portion of the gas coal at such a low temperature as will produce liquid tars comparatively free from naphthaline but rich in vapors having vapor tensions similar to that of naphthaline. The naphthaline charged gas, as it leaves the ordinary condenser, when mixed with the hot gas and products from the coal carbonized at the lower temperature, has the major part of the naphthaline vapors dissolved out by the liquid tars as these are precipitated, while at the same time the gas takes up in diffusion the vapors of hydrocarbons which have tensions approximating to that of naphthaline.

These are present in large quantities in the low temperature products, and during the distribution of the gas so treated, they prevent any naphthaline which may remain from being deposited in the crystalline form, for these vapors condense along with it and take it up in solution.

When it is desired not only to remove the naphthaline from the gases produced from coal carbonized at high temperatures, but also to raise the illuminating power, that object can be most conveniently—and, with 90 per cent. benzol at its present price, very economically—effected by adding to the dense oils, used to remove naphthaline, more benzol than is necessary to balance their solvent power for the benzol present in the gas. The excess quantity volatilizing into the gas would raise the illuminating power, and by regulating the quantity of benzol so added the desired illuminating power can be maintained with great regularity.

Where cannel coal is available at a reasonable price, the same objects may be obtained, even more economically, by carbonizing the cannel at lower temperatures than that employed for the gas coals. The cannel coal carbonized at the lower temperature yields liquid products which have a very high solvent power for naphthaline, and it also yields a large volume of hydrocarbon vapor, which can be taken up in diffusion through the gas, and which possesses an enriching value of nearly twice that which can be obtained from the same cannel carbonized at higher temperatures along with the ordinary gas coals.

*Discussion.*

The President, in opening the discussion, said he did not intend to make any remarks upon the paper as there were so many gentlemen present who had had great experience of this elusive compound.

Mr. J. P. Leather (Burnley), on being called on by the President, said he had not much to add to what he said last and to what was given in the paper. There was nothing in the paper but what he entirely agreed with. His further experience confirmed the opinion of Mr. Young that it was possible to take the naphthaline thoroughly out of the gas, without deterioration of the gas, and without incurring any great cost, and, of course, if the naphthaline was taken out it could not give trouble afterwards.

Mr. J. W. Morrison (Sheffield) said it was pretty well known that at Sheffield they had been very seriously troubled with naphthaline. There were three works. At the Grimesthorpe station they had been practically free since the works were started, and remained free up to the present. There they had settings of 10 retorts in each bed, and they ran at pretty high heats to carbonize the coal, which consisted of slack and small nuts. With these conditions anyone would expect to find a very large quantity of naphthaline in the gas. The foul mains on these works were originally intended for a production of 5 million cubic feet, but at present they were not making more than 2½ million cubic feet. He had recently had occasion to open a Clapham washer which had become temporarily blocked, and after turning steam into it for a few days the first purifier they opened was found to contain very heavy crystals of naphthaline. This had not been noticed before or since. There had been no complaint in the district, and it puzzled him to find the naphthaline there. At another works, which supplied rather a hilly district, they had been very much troubled formerly, and he was sorry to say the complaints had started again this year. They had generally found that the worst trouble was in the higher districts, in cold clay ground, and where the mains ran to a dead-end. Where they had been able to couple them round, they had in many cases been able to get rid of recurring complaints. He had also had experiments conducted by passing gas containing naphthaline through the lighter tars taken from the foul mains and the condensers, and so far the results had been very satisfactory. He was at present collecting the tars, with the idea that if the naphthaline difficulty should again crop up they would be able to wash the gas in the lighter tars, and they had found by experiment that, by keeping the tars at a temperature just over 90°, they could remove the naphthaline without robbing the gas of any illuminating power.

The President expressed surprise that there should be such unanimity on this question of naphthaline, upon which he had understood there had hitherto not been much agreement. There seemed to be no difference of opinion that it could be cured, and this was a great blessing for gas producers. It would be a mercy for one or two of his own clients who had been growling about it very considerably and who had not yet been able to cure it. After hearing the paper, he would doubtless be able to advise that the removal of naphthaline was as easy as getting the ammonia out of the gas. They were indebted to Mr. Glover for having read Mr. Young's paper.

Mr. Glover said he did not think it necessary to add anything to what had been contributed in the paper. Mr. Leather's further experience confirmed the experience he related twelve months ago, and Mr. Morrison also confirmed the method of removing naphthaline from coal gas by washing the gas in the lighter tars, which were, of course, excellent solvents of naphthaline. He was sure that if Mr. Morrison would carry out this process on the lines put forward by Mr. Young he would eventually find a complete cure for naphthaline at all his works.

## Opportunities for Establishment of Electrical Plants in the Philippines.

By Mr. G. D. Rice, in *Electrical Engineer*.

There is a very good opening for the establishment of electric light systems in the Philippine Islands. The writer recently returned from an extensive tour of the southern islands, including all of Panay, and portions of Negros, Cebu and Minandao, the principal islands of the Philippine group aside from Luzon. In Luzon, which is, of course, the most important of all, there are already many electric lights in operation in Manila and in the chief coast cities.

While Spain had control of the islands the idea seemed to be to keep everything back, it being stated that she would not permit even the rich owners of sugar plantations, rice fields, etc., to purchase modern machinery for working their products, and the woods of the Philippines have been neglected for generations for the same reason. As soon as the Americans have taken a city, town or barrio, they go to work and put the same into American condition. In some sections the process of Americanizing has progressed at a remarkably rapid rate, and to day men and women who were practically in a savage state are asking for the modern improvements of America, such as sewing machines, bicycles, modern machinery for handling the immense forests of valuable woods, machinery for working sugar, tobacco packing, electric roads, lights, ice making machines, etc. There are many rich men here, and if an American were to come here with the proper models and plans for the introduction of an electric power station for lighting the community, at such a place as Iloilo, Negros or Cebu, he would find no lack of money for the enterprise.

At present, outside of Manila, the only means of lighting is with petroleum oils shipped into this country from Russia, England and the United States. Most of the packages of illuminating oils appear to be stamped as from Russia. The cost of the oil by the time it reaches the consumer in these islands is very great as compared with ordinary American values. The result is that the poor native families go without oil light and burn wood, or do without light at all. The moderately well-off people use about one lamp for a household, while the rich, of course, burn oil as they please. The Americans and foreigners here use imported American lamps and burn what oil is needed.

Although there are no means of getting gas for illuminating purposes in these native cities and towns, vast gas wells exist in the mountain ranges. At one of these, in a section of the country where they said white man had never been before, I put bamboo poles in the earth and lighted the gases as they came from the top, producing a steady, clear and strong flame. At another place I found indications of oil wells. These wells have been found in various parts of the islands, and may in time amount to something. At present they are useless.

What is wanted here is a system of electric lighting, and it is bound to come very soon, for everything is inclining that way. One of the first thoughts in connection with the establishment of electric light systems in a new country concerns the power. Steam power is available, of course, but the cost of getting a steam plant of large size to these islands will be expensive. However, it can be done, and has already been done by manufacturers of ice, woodworkers, machinists and others; but up in the mountains of Panay—and the same conditions exist in nearly all of the important islands—there are certain water powers which could be developed by collecting several streams into one body and carrying the latter to a given point in the valleys for use for operating water wheels. The opportunities for putting in open flues and tunnels for the purposes of carrying the water the required distance are favorable, as there is plenty of good timber available, and native labor on this sort of work is exceedingly inexpensive. The waters gathered at these elevations could be carried to the sea level, or to the desired points at the seaport cities, and there utilized in the operating of the power plant.

Some would, of course, favor a steam power plant, and if such a plant is put in, the power development should be greatly in excess of what is needed, and the surplus power rented to the many machinists, wood working establishments, sugar plants, etc., which are now operated by caribou power in all of the cities and towns at the seaports, and often in the interior. The caribou is a big, steady and strong animal, very slow in action, but can take a heavy load behind him for long distances. These animals are secured to the walking beams of turning power devices in the shops, and in that way a very irregular, slow and unsatisfactory power results. The few manufacturers and others who are fortunate enough to possess steam power plants have only what power they themselves need, and will not rent any of the power. There is, therefore, a great demand for power, and an electric lighting power company could derive a good income from the renting of power to small parties.

The power plant of the electric light station can be operated cheaper in this country than in America, for the reason that the cost of labor hire for all but the chief engineer and the fuel account are much lower. The head engineer and machinist would have to be engaged in America, and brought here to supervise the erection of the plant and later on to take charge and instruct natives in firing and to act as assistant engineers. These native assistants and firemen can be secured for the regulation rate of wages of 20 to 25 cents per day of American money, and they live well and save money on these wages, although they support themselves and provide themselves with lodgings out of it. As to the wood for use as fuel, this is secured from the banks of rivers and streams in abundance after the rainy season, for the high waters carry the broken logs from the woods to the river, and as soon as the river settles the natives go in with the caribou and secure logs, which they sell in the cities and towns for firewood at the rate of about one dollar gold per cord. This wood makes good stuff with which to raise steam, and it can be bought in vast quantities.

Less than six months ago it would have been unsafe for electricians to go far from the seaport cities garrisoned by American troops for the purpose of putting in electric light wires. Last November the battle of Balangtang was fought in the island of Panay, immediately after which the insurgents were driven to the hills in small bands and the native army of Panay has since gone to pieces, so that to-day almost everywhere one sees the signal corps men of the United States Army putting in wires for connecting signal stations from one side of Panay to the other. Practically the same conditions prevail in Luzon and the other islands. It is safe for wiremen to go almost anywhere in the islands now, providing that they carry rifles and have with them a small guard. It is customary for the signal corps men to go in squads of about six men each, all armed with revolvers or rifles, and as they operate between posts garrisoned by the United States soldiers, the commanding officer of the station next to them provides as guard about four armed men. The same facilities for protection would be given wiremen who would put in electric wire systems for connecting one town with another. By the time an electric light company were to get to work the riotous times would be at an end and no guards required. But the American officers of the troops here are always very willing and glad to lend protection to new interests, whether controlled by Americans or natives. If the owner of a sugar plant wants protection from roving guerillas, he is supplied with a squad of men to protect his property, and nobody cares whether he was or was not once an officer or a private in the insurgent army.

Poles for the wires can be secured very cheaply. There are vast forests of excellent woods of all kinds going to nothing in these islands, and fortunes are being lost to somebody every year; if it can be looked at in that way, presumably the time will come when these magnificent forests of great old trees of mahogany, black walnut, etc., will be utilized for something else than ordinary house and table woods by the natives, or permitted to rot in the swampy jungles, as many valuable woods are now doing, for lack of some one to cut them and ship the rich products to the markets. The bamboo poles of the islands are perfectly straight, of course, and the signal corps men have used these in large numbers for stringing the signal wires for telephone and telegraph across the islands. They have the natives cut the poles, and the natives do this sort of work for 15 to 20 cents daily, American money, so that the cost per pole is only a few cents. In getting these poles, an electric light company could go into it deep enough also to cut mahogany and ship enough of this valuable wood to America or other ports to pay for the entire cost of putting in the wires.

An electric light company should not come to the islands expecting that it can string its wires from seaport cities and towns to the interior towns and barrios without considerable labor in getting from one place to the other with the necessary apparatus. The roads of the Philippines, except in the cities and towns, are unfit for service about six months out of the year. The worst time of the year is in November, when the last of the floods due to heavy rains are felt. The roads then become overflowed, unless graded, and the hollow places become soft mud, into which the drag sleds of the caribou and the wagons of the mule trains of the army sink until they are almost put out of service. The writer was with one ration train which covered only about two miles per day in the latter part of last October because of mud and water. During the dry season, however, the roads get sun-baked and hard and firm, so that the drag-sleds of the natives slide off the surfaces freely and the wheels of the heavy wagons ride easily on the level top. It is during this time, which extends from December to June, that the

electric light company should put in its best work in stringing wires.

In nearly all of the cities, towns and barrios of the islands there are certain natives who make a business of caring for the street and house lamps at so much per lamp per night. It is a custom here for all houses and shacks in the communities to have lights, one each, in front, all night—usually a lantern-shaped affair made by the native workers in metal. The cost of burning these lights and the lights used for house hold purposes may equal almost the entire cost of the food for a portion of the family. It costs only a few cents per day for the rice and simple food for a native. It would be only necessary for an electric light company to put in its plant and wait results. The rich natives would quickly flock into the office and place their orders for lamps, and the business element would follow. The presidents of the towns would put in the lights for lighting the streets, the church, the market place and other properties under their control. The natives have money for this purpose, and some of them have much of it. The cost of present systems of lighting being high, the slight additional cost for electric lights would not prevent the average native from putting in the same. The natives want everything new and modern, and are fast learning to do things like Americans and to call for things as we do. For example, when the writer arrived here last year, almost all of the natives seemed to be in breech cloth only. The Americans objected to this sort of thing, and made the natives buy white suits and wear them. The natives objected at first, but took it good naturedly in time. It was an amusing sight to see a big American soldier chasing a little, brown native in breech cloth; finally catching the native and walking him to a tailor's and making him have a white duck suit made. I once saw a soldier march into a tailor's shop with four natives, two held by each hand by the breech cloth. The natives seemed to take it as a joke and laughed heartily; but they had to get into clothes. Once in clothes, they must have shoes, and then a hat, and so on. Once equipped in this way, they never go back, but strut in their new Sunday white clothes, taking pride in them. All this leads to higher and better ways of living, and to a desire for things modern, such as electric roads and lights; so that the present conditions for the establishment of electric light and power systems in these islands are very favorable.

There is a great deal of capital here in the possession of the rich natives ready for investment. I have had the wealthy classes in all sections come to me and ask advice concerning the investing of gold and silver money, which has been stored in chests in the earth beneath houses in the islands for a long time. Some of this money is badly tarnished, but is all right for circulation. The rich native sugar mill owners and others never dared invest money to any extent under Spanish rule, for they feared that as soon as it was known that any one had money to invest, Spanish officials would get hold of it in some way. Nor was it safe to put money into manufacting enterprises, or even the banks. There is one bank in Iloilo and several in Manila. If the native merchants carried much of a stock of goods, there was danger of its being confiscated or taken by the warring tribes of the islands, and consequently no one carried much of a stock of anything. I recollect when first coming to the islands, at Molo, on Panay, there were reports of attacks by the insurgents one night and a riot started; and as the frightened people rushed through the streets, certain of the rough native element stole all the goods they got hold of in the stores and rushed along with the mob to the outskirts of the town, there to take away the goods to the mountains. This sort of thing discouraged any one from establishing new works. But now that American troops have practically cleared the territory of the rowdy element and compelled the warring soldiers of the insurgent army to put aside their weapons and go to work at the plow or the bench, the situation has so changed that it is perfectly safe for an enterprising American to start electrical works in these islands.

## The Merrill Automatic Lubricator.

The lubricator here illustrated, which was patented by Mr. G. U. Merrill, of Paterson, N. J., is to be attached to any reciprocating or oscillating parts of engines or machinery requiring constant and reliable lubrication, such as the cross-heads, connecting rods, eccentric straps, etc., of engines, pumps, air compressors, etc. As it feeds grease instead of oil, it may be attached in any position desired, feeding vertically upward or downward, horizontally, or at any angle desired. It feeds only when the part to which it is attached is in motion, and no feeding or loss can occur after the motion ceases.

The base of the lubricator is screwed firmly into the part to be lubricated in the usual way. The body is attached to the base by the union

nut or enlarged ring at the bottom. When this is unscrewed the upper part is all taken off together, the barrel is filled with a charge of grease and returned and securely clamped in the position again by the union nut. The feeding is accomplished by the pressure of the piston, and this pressure is applied by the vibrations of the pendulum seen in the front. By the adjustment of the stop-screws at the side, the pawl attached to the pendulum may be made to take from one to six or more teeth of the ratchet wheel for each vibration. On the ratchet-wheel shaft is a worm which meshes into the large worm wheel at the top. The central screw or spindle is splined and revolves with this wheel at the same time that it travels downward by the operation of its thread in the central nut, which is screwed into the bracket or guide at the top. The feeding goes on if the vibrations continue until the piston reaches the bottom and the grease is all expelled. To raise the piston for refilling the barrel, the central nut, which has a milled and notched head, is unscrewed from the bracket, the piston is pulled, the nut is whirled down the screw by hand and screwed tight in its place again. The ratchet wheel may be pulled around by hand, until the slack is taken up and feed is fully established, and if at any time it is desirable to feed in an extra quantity of grease this also may be done by turning the ratchet wheel. The lubricator may be made of any size and for any rate of feed desired. The one here shown will hold about 14 cubic inches, or somewhat less than half a pint of grease. The ratchet wheel has 100 teeth, the spindle wheel has 125 teeth, the central spindle is 24 threads to the inch and the travel of the piston is 3¼ inches. If, then, the pendulum is set to take two teeth of the ratchet wheel for each stroke, the number of strokes required to empty the barrel will be 525,000, and at 200 strokes per minute this would last 2,625 minutes, or, say 45 hours. Any of the usual kinds of grease may be used in the lubricator and any percentage of pure graphite may be mixed with it. The worm is of steel, the pawls are of steel hardened and the wheels are of hard bronze.

## Electric Heating and Cooking.

The *Electrical World* says that it is interesting to observe the gradual but steady advance of electric heating for culinary purposes in large cities. We take it for granted that electric heating on a large scale cannot be efficient or economical, except in very special instances. Thus it is out of the question to consider an electric heating plant for raising large vats of liquid to the boiling point unless there are some very special reasons why chemically evolved heat may not be used. A kilowatt-hour in heat is about 3,600 B.T.U. and costs a consumer in our large cities from 5 to 20 cents, according to the conditions, or from 72,000 to 18,000 thermal units per dollar. On the other hand, a short ton of ordinary good steam coal will contain 28,000,000 of B.T.U., and allowing a loss of 25 per cent. in a boiler wall and flue, some 21,000,000 of heat units can be looked for in the boiler water, such coal costing about $1 to $3, according to circumstances, and representing a yield of from 21,000,000 to 7,000,0000 of thermal units per dollar, or in the neighborhood of 300 times more heat than the electric method would furnish. The comparison is in a certain sense unjust, seeing that the retail price of electric energy on a small scale is compared with the manufacturing cost in fuel alone for heating water on a large scale, and a far better relative showing could be made where both methods were compared from either the manufacturer's or the purchaser's

standpoint, whatever the scale of production might be; for example, where a large turbine drives a generator below full load, the cost of supplying electric heaters in the power house may be practically nil, no extra labor being required beyond the act of connecting or disconnecting them, while the water power runs unpriced. The only reliable statement that can be reached applicable to all conditions is that where heat is obtained from combustion, it must be much cheaper to produce the heat directly where required, than to supply the heat to an engine and dynamo and reproduce the heat electrically, seeing that the efficiency of the boiler, engine, dynamo and transmission wires can hardly be more than 15 per cent. and is commonly less than 5 per cent.

It is only on a large scale, however, that price sways the scepter. On a small scale price often becomes insignificant by comparison with comfort and convenience. It is declared by some builders from their actual observation, that so great is the influence of personal convenience, that stores on the lightly frequented side of a street may relatively languish, while stores, no better in attractions, on the densely frequented side may thrive. In other words, it is said that the mere effort of crossing a street by a purchaser will markedly affect his choice of a store. It is the same law in another form which causes the price of a retail article to be often twice and sometimes twenty times as great as the cost of the same article on a larger scale. Where a small quantity of heat is required for cooking, the advantage is altogether in favor of the electric method. A small electric stove is probably as cheap in fuel consumption as a small coal stove, and is devoid of smoke, dust and ashes, besides requiring neither matches nor kindling wood. The electric stove can also be made more compact than the coal stove, and can better retain its heat to the exclusion of surrounding objects, which is a decided advantage in the torrid days of summer. The comparison with an oil stove or a gas stove is less favorable to electricity, but even here the electric stove has the advantage in cleanliness and convenience.

## Recent Progress in the Aluminum Industry.

In a paper on this subject, read by Prof. J. W. Richards, of Lehigh University, at a meeting of the Franklin Institute, he said: It is not yet 75 years since aluminum was first isolated as a metallic powder, and not yet 50 years since it made its appearance as a true solid metal, while until 15 years ago its price was counted in dollars per pound, and it was used only for articles of luxury or for purposes where lightness was a desideratum and expense was not considered. From 1884 to 1891 several new processes of production followed each other, reducing the price nearly 50 per cent. each year and causing the output of metal to increase nearly 100 per cent. each year, until with the present decade aluminum became a metal of every day life, for it began to compete with such ordinary metals as German silver, britannia, pewter, bronze, copper, and even brass. To-day sees this new metal firmly established among the every day metals, known to and used by the general public, and destined to ever increasing usefulness until its only rival will be iron and steel.

*Process of Reduction.*—My further remarks will concern only recent advances, and in the line of pure metallurgy—that is, reduction and refining, there is little to chronicle. The process of reduction has certainly been somewhat improved in details, but in principle it is the same as the Hall process of 10 years ago. The operators of the process are naturally averse to publishing the details of their operations, and the outside public is vouchsafed information only upon the properties and utilization of the metal. About all there is to be said is that during the last few years all the items of expense of the process have been gradually notched down—bauxite is being mined and prepared better and more cheaply; its conversion into alumina is probably improved; electrolytic carbons are being made cheaper and more durable; electric power is being obtained more cheaply, and, finally, the doubling and doubling again of the size of the works has reduced correspondingly the cost of superintendence and office expenses. These, and probably several other items of saving, have altogether reduced the cost price of aluminum to probably about 20 cents per pound, while its selling price is slightly over 30 cents in the United States and 25 cents abroad. I could wish to be free to give more information on these metallurgical details, but since that is denied, I will pass on to the varied uses of aluminum which have recently appeared.

*Displacement of Other Metals.*—Here is a small box containing a dozen aluminum thimbles, which was sold in the largest store in this city this week for 5 cents. This furnishes me a good text to talk about the displacement of other common metals by aluminum. These dozen thimbles weigh less than ¼ an ounce, and the aluminum in them cost the manufacturer just 1 cent. If he had made them of common brass, they would have weighed 1¼ ounces, and the metal in them have cost 1¼ cents, which is an increased cost of metal of 75 per cent. Or, stating it another way, to manufacture $1,000 worth (selling price) of thimbles, the manufacturer would have to buy to make them (allowing 25 per cent. for waste clippings) $250 worth of sheet aluminum, or $437.50 worth of sheet brass. The general public considers brass as a cheap metal, and such facts as the above are rather startling when first grasped.

Coming to the city in the train to-day I estimated the amount of brass fittings on one railway car as about 300 pounds. Without exception, they were replaceable by light aluminum alloy, which, fully as strong, would weigh only 100 pounds and cost only two-thirds as much. The difference in cost would probably amount to $20 per car in favor of aluminum, while the saving in dead weight hauled would be more than the average weight of one passenger per car.

Such instances as the above could be multiplied *ad libitum*, but these suffice to prove the point, little apprehended by the general public, that for almost every practical purpose aluminum is cheaper than all the common metals excepting zinc, lead and iron. Brass, tin, copper, are of approximately the same specific gravity, and in comparing their costs we usually think only of their relative cost per pound; but aluminum is entirely in another class. It takes only ⅓ pound of aluminum to take the place of 1 pound of these metals, and the proper basis of comparison here is to compare the price of ⅓ pound of aluminum with that of 1 pound of brass, etc. The comparison, therefore, stands as follows:

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|---|---|
| One third pound of aluminum | 11 cents. |
| One pound of brass | 15 " |
| One pound of copper | 17 " |
| One pound of tin | 30 " |

*Aluminum Utensils.*—The use of aluminum for culinary utensils is extending steadily, as their merits become better known. A brief statement of what they are for this purpose is that they possess all the advantages of copper utensils, with none of their disadvantages. The first aluminum utensils put on the market ten years ago were generally too lightly made and were consequently easily dented and bent out of shape. The manufacturers have learned by experience, so that the ware now being sold is fully as durable as the best copper ware. An aluminum kettle in my father's house has been on the stove constantly for seven years, boiling Schuylkill water, and is apparently uninjured and unworn. The inside has a brownish adherent skin of oxide which seems to be continuous and to efficiently protect the metal beneath from further oxidation. It bids fair to become an heirloom in the family. There are at present a full dozen firms engaged in manufacturing this culinary ware, and it is now so generally known that it was unnecessary for me to display any here as a novelty. This small *bonbonnière*, made by Hill, Whitney & Co., of Waltham, Mass, and modeled after the famous silver porringer hammered out by Paul Revere, is interesting as to its shape, as well as showing the beautiful finish, inside and out, which can be given aluminum ware.

*Aluminum Workers in India.*—As a district novelty in aluminum goods may be mentioned the beautiful ware being made by the native metal workers in the bazars and industrial school at Madras, India, under the leadership of Mr. Chatterton. These native workmen are probably the most skillful metal workers in the world, and their work is principally confined to steel arms, silver ornaments and copper and brass utensils. The fact that aluminum sheet blanks can now be purchased cheaper than similar sized blanks of copper or brass has given the opportunity to introduce the working of aluminum. The natives have easily mastered the peculiarities of the new metal and take most kindly to it. The native Indian troops are largely supplied with aluminum ware, and it is coming into favor in all castes, from the lowest to the highest, on account of its lightness and cleanliness, while costing no more than copper or brass utensils.

*Aluminum Novelties.*—It would be useless for me even to attempt to name all the various goods which are now being made of aluminum, in which its lightness and prettiness are much in evidence. The toilet goods and pocket articles are especially in favor, and aluminum combs are being made by tens of thousands and consuming a generous share of all the aluminum sheet made. An equally large use is for fruit jar caps, for which aluminum is superseding zinc, although more expensive, because of its harmlessness.

*For Electrical Purposes.*—Electric conductors can now be laid more cheaply in aluminum than in copper. This is indeed a startling statement when first heard, for almost every one is wont to consider

copper as the metal *par excellence* for conductors. But pure aluminum has over 60 per cent. the conductivity of pure copper, and is fully as strong and resistant to atmospheric influences. It is therefore only necessary to take an aluminum wire one-fourth as large again in diameter as a copper wire (giving a little over 50 per cent. more section) to get equal conductivity. Such a wire weighs one-half as much as the copper wire it replaces, and costs only two thirds as much. Long distance transmission lines and trolley feed wires are being put in aluminum as fast as the makers can supply the metal. Over 500 tons of aluminum were used for this purpose last year, and probably double as much will be used this year. As 500 tons supplants 1,000 tons of copper, it will not be long before the copper industry will begin to feel the competition of aluminum, but will probably be unable to meet it. This one use of aluminum promises in the near future to consume its thousands of tons a year. What a contrast to the industry 15 years ago, when 2½ tons of aluminum was the output of the whole world in one year!

*Aluminum Powder and Paint.*—It is now necessary for me to rapidly bring my remarks to a close, and to leave unnoticed many interesting items which might be mentioned did time permit. I will close by referring to powdered aluminum and the many applications it is receiving. Aluminum can be rolled out to $\frac{1}{10000}$ inch in thickness, and then beaten out to $\frac{1}{100000}$ or even $\frac{1}{1000000}$ inch. As thin sheet it has found some application in place of cardboard, for business cards, etc., but as leaf it has entirely superseded silver leaf in decorating. This leaf can, moreover, be ground to powder, and in this condition is used by printers for silvery printing, and as a paint. For the latter use it is simply mixed with a varnish, like ordinary bronzing powders, and has already proven its beauty and utility on Uncle Sam's letter boxes. Every one here has had the opportunity of seeing this use and judging for himself of its practicability.

## Electrical Measuring Instruments.

[A paper read by MR. J. FRANKLIN STEVENS at a meeting of the electrical section of the Franklin Institute.]

In attempting a brief discussion of so broad and comprehensive a subject as that assigned me for this evening, I have been principally concerned in trying to decide just what portion of the general subject I should touch upon and in what manner I could treat that portion briefly, for I cannot hope to be comprehensive, and yet have my remarks present a semblance of coherence.

Since we have available a very extensive literature bearing on the subject of laboratory testing instruments, in which can be found descriptions of the instruments employed, their construction, application and approximate laws, I shall pass over that portion of the subject and confine myself to commercial direct reading indicating instruments, such as are to be found in everyday use.

The history of the art embodied in the commercial manufacture of indicating instruments is extremely interesting, but shows many analogies to the development of other branches of electrical engineering, with the single exception that practical data in published form is extremely scarce. Every one entering this field is compelled to master some of the most intricate problems known to the profession, and must learn for himself how best to apply theoretical deductions to practical mechanical devices. Until very recent years, our sole guide has been the study of early and primitive types which in their time were useful and valuable, but which to-day fail to reach the high standard we have learned to demand of an instrument whose function is to indicate the input or output of our many and varied electrical devices. Every new device put before the public has meant a new condition to be met by the instrument manufacturer, requiring of him a new design or modification of an existing design. Two rather recent examples of this occur to me; one, the increasing tendency to employ high voltages in commercial work, reaching frequently 12,000 volts in the case of series constant-current arc light systems and 33,000 volts in long-distance power transmissions; the other, the rapid development of the electric automobile, which requires a volt-ammeter of as high a degree of accuracy as the portable laboratory instrument, yet able to withstand the roughest usage ever accorded an instrument of precision, coupled with restrictive specifications as to size and weight. In every instance instrument manufacturers have met the demands made upon them better, I think, than many of our fellow-workers have in some other lines. Much yet remains to be done, and much, I am confident, will be done in the matter of perfecting existing instruments in the near future. Gradually inefficient or unreliable types are being relegated to oblivion, and the remaining ones brought closer and closer to standard uniform construction.

The greater number of measurements required to-day can be made with a voltmeter, ammeter and wattmeter, and, while it might be thought that the wattmeter is merely a combination of the voltmeter and ammeter mounted in one case, this is not true in all classes of measurement. While it is true that the reading of the wattmeter represents the product of the readings of the voltmeter into the ammeter in the case of direct current measurements, it is not true in the case of alternating current measurements, save in the very exceptional case of a circuit possessing neither capacity nor inductance or a balance of the two. When either inductance or capacity exist there is a consequent lag or lead of the current wave relative to the pressure wave, and, since the instantaneous readings of the volts and amperes represent the mean effective or virtual values, that is, the square root of the mean square, their product differs from the reading of the wattmeter, which indicates the integrated values of two curves, the maximum and minimum values of which occur at different times. To obtain an agreement between the values obtained by volt-ampere readings and watt readings, it is necessary to multiply the volt-ampere readings into the cosine of the angle of lag or lead, so that the ratio of the watt readings, as given by a properly constructed wattmeter, to the volt-ampere readings gives us the power factor of the circuit, and from the two sets of readings we can readily determine the angle of lag or lead and the so called wattless current. Probably this is well known to all of you, yet scarcely a week passes but I have to explain the matter to one or more customers who cannot reconcile the difference in the two sets of readings and are inclined to believe that some, if not all, of their instruments are indicating erroneously.

Before touching on the different types of indicating instruments which are most commonly found in commercial use, let us consider for a moment the essential requirements of a practical and satisfactory instrument for measuring voltage, current or power. To start with, the instrument must be direct reading. We have no time to-day to convert angular deflections into true values by means of tables of constants, but insist that the pointer shall indicate directly in definite units the value of the passing load or the impressed electro-motive force. We must next be assured of the accuracy of the calibration, and for that depend principally upon the reputation of the maker or check the indications by comparison with a secondary standard. Beyond this we must know that the accuracy of the indications is not affected by influence of the ordinary external fields or by normal variations of temperature, due either to heating within the instrument, by means of the passage of the current to be measured, or to variations in the temperatuse of the room in which they are installed. All instruments should be mounted in dust proof cases, and the systems carried in jewelled bearings; the movement of the pointer should be aperiodic or dead beat, and, so far as possible, the system should contain nothing subject to change or deterioration, and should be constructed so that it will withstand successfully the ordinary rough usage liable to be accorded it in practice. The question of gradual change of accuracy, due to the change in some constituent part of the system, has led me to strongly advocate the use of electro-magnetic instruments with gravity control for switchboard use whenever the conditions render them applicable, and I fully expect to see this type of instrument become more popular as its advantages become more widely appreciated. Such a system is not applicable for portable instruments, save the dynamometer system for alternating currents, and even then a spring control must be used; nor is the series electro-magnetic ammeter practical above about 1,500 amperes, due to the structural difficulties involved in carrying the bus bars directly to the instrument terminals. The one objection most commonly urged against the electro-magnetic instrument for direct current switchboard use is the unequally divided scale, for, as a rule, the scale only covers a range starting at 10 per cent. of the total up to maximum. In most cases, however, this objection is purely captious, for a switchboard voltmeter is seldom used to indicate more than 10 per cent. above or below the normal voltage, and the ammeter indications are of principal importance in the higher ranges to prevent a possible overload of the circuit or generator. In alternating current circuits an equally divided scale is an impossibility, so why should we sacrifice constancy in direct current measurements for the sake of an equally divided scale when the lower registers are so seldom used? In portable direct current instruments the proposition is somewhat different, as we desire to cover the maximum limits of possible measurement on a single scale instrument; therefore, an equally divided scale is desirable and practically necessary.

Taking up now the different types of instruments which are in most

common use, we find they may be roughly divided into six classes, depending on the principle by means of which measurements of voltage, current or power are made: (1) the hot wire; (2) the tangent galvanometer; (3) the electro static; (4) the dynamometer; (5) the D'Arsonval galvanometer, and (6) the electro magnetic.

The hot-wire instrument is designed to operate by the expansion of a fine wire or strip of conducting material due to the heating produced by the passage of the current to be measured, and, therefore, the indications are proportionate to the square of the current. This type of instrument possesses the advantage of indicating with equal accuracy the current flow on either direct or alternating current circuits and is independent of the frequency of the circuit or of the shape of the current wave; it is, further, unaffected by the presence of external fields.

These advantages, however, are all that can be claimed for this system, and to offset them are many serious disadvantages. Since the instrument operates by virtue of temperature differences, it is extremely susceptible to variations of external temperature, and such variations must be compensated either by mechanical means, which provide for bringing the pointer to zero by increasing or decreasing the tension on the working wire, or by providing auxiliary heating strips which are supposed to automatically adjust the tension of the working wire on the general principles of a thermostat. This may seem a small matter to most observers, but to me it signifies an error in principle, and reminds me of one of our early types of arc dynamos which, by reason of incorrect construction, was found to spark badly; so, in place of correcting the design, an air blast was provided to blow out the spark. Another point of objection is the constant change of zero, due to the fact that until the wire has been stretched to its elastic limit it will fail to return to the same point after having been stretched by the heat applied and will always show a slight residual strain. To attempt to correct this prior to installation in the instrument means, judging by my own experience, that at least 90 per cent. of the wires will break during the preliminary stretching process, and the remaining 10 per cent. will stand but a very slight overload in service. As overloads are quite common, this would constitute a serious objection, for it means the return of the instrument to the manufacturer for the insertion of a new wire and recalibration. Another very serious objection is the amount of current required to operate the instrument. The average resistance of a modern hot-wire voltmeter is 4 ohms per volt, which means a current flow of .25 ampere. This low resistance effectually bars this type of instrument for accurate testing, since the amount of power abstracted from the circuit to be tested vitiates the accuracy of the results obtained and introduces serious errors, which must be allowed for in all calculations.

Recently an attempt has been made to introduce the hot-wire instrument as a shunt ammeter, particularly for alternating current measurements. As a shunt ammeter, the hot-wire instrument is a distinct failure, for, while the manufacturers claim it can be operated on a drop of .3 volt for full scale, my personal experience has shown a drop of 6 volts to be necessary. On the makers' figures, 300 watts would be required to operate a 1,000 ampere ammeter, nearly .4-horse power per instrument, while on the sample I have tested 6,000 watts, or 8-horse power, would be required. Again, it has been shown that these ammeters when calibrated on direct current are not accurate within 10 per cent. when used on alternating currents, unless the reactance in the shunt is exactly equal to the reactance in the instrument, a condition almost impossible to obtain, even with the most careful design.

A modification of the hot-wire system has been proposed, consisting of an enclosed chamber containing a fixed resistance wire, one end of the chamber, which is made air-tight, consisting of a flexible diaphragm operating the pointer through a system of levers. In this case, the heat supplied to the wire by the passing current causes the air in the inclosed cylinder to expand and, consequently, puts the diaphragm under tension, very much on the principle employed in the aneroid barometer. I find by actual experiment that such a system could be applied to voltmeters, and could be so made that it would be accurate in its indications and would possess a reasonably high resistance. The feature, however, which renders this system impracticable is the slowness with which the readings can be taken. The pointer will not come to rest until after the heat supplied the air inclosed within the chamber is equal to the heat radiated by the walls of the inclosing chamber, and from 1½ to 2 minutes are required before the pointer will come finally to rest at the part of the scale marked to indicate the impressed E.M.F. This is true no matter how small the air chamber is made; and while it is possible to shorten this time by carefully covering the sides and one end of the cylinder by a heat insulating jacket, still it cannot be constructed so as to give an instantaneous reading, and every attempt to shorten the time by covering the walls of the chamber results in a corresponding increase of the time required for the pointer to come back to zero after the current has been shut off. In other words, the instrument is similar in its action to an ordinary thermometer, which, as you know, cannot be made to respond instantly to changes of temperature.

Electrostatic instruments, which depend for their action on the mutual attraction of two plates connected to the opposite sides of the line, are still used, but not extensively, for high tension measurements. They will indicate correctly on either direct or alternating current circuits, but are limited to measurement of voltage. It is impossible with this type of instrument to obtain a low reading, as the attraction of the plates toward one another varies approximately with the square of the potential difference between them. I say "varies approximately" advisedly, as the capacity of two plates varies directly with the square of the voltage only when the distance between the plates is maintained constant, which in this case is an obvious impossibility.

As a rule, these instruments cannot be made dead-beat without introducing elements liable to seriously interfere with their accuracy; and, while there are no errors due to temperature changes, and while they are also extremely efficient, requiring no current flow at all, they are affected very considerably by external influences, particularly by static charges, which are almost invariably present in power stations or dynamo rooms, and, as you probably know, it is practically impossible to provide a shield for static effects.

Instruments employing the principle of the tangent galvanometer are still employed, and for certain classes of measurements are extremely useful. They can be particularly recommended for use as ground detectors or differential voltmeters, where the actual value of the indicators is of small moment, the particular object being to show a balance of two opposing voltages or the presence of a ground by deflection. In this system the magnetized needle is suspended vertically, and is acted upon by two equally and oppositely wound solenoids; that is, the solenoids are wound with two wires in multiple and then cross-connected, so that we have two circuits equal in effect but opposite in action. I might say in passing, that if the proper proportions of solenoids to magnetized needle are employed, and the length of the magnetized needle properly proportioned to its area, the tangent galvanometer instrument may be made extremely accurate and also quite permanent. Care must be taken, however, that under no conditions can the direction of the lines generated by the solenoids oppose the lines existing in the magnetized needle, otherwise the value of the calibration is almost instantly destroyed.

For measurements of alternating current voltage, and also for the measurement of the watt output of any alternating current source of energy, the dynamometer system, in one of its many modifications, is unquestionably the best type of instrument that can be used. This instrument indicates directly the mean effective voltage of the line to which it is connected, and is equally accurate for direct current measurements, provided readings are taken with the direct current flowing through the instrument in one direction, then the direction of the current flow reversed and a second reading taken, the mean of the two readings being the correct value of the impressed electro-motive force. This for the reason that the instrument is extremely susceptible to the influence of external fields. Further, the dynamometer type of instrument is only properly adapted for use in portable instruments. The fact that two readings are necessary on direct current prohibits its use as a switchboard instrument on direct current circuits, and its delicacy, coupled with its field of low intensity and its susceptibility to error, due to the presence of iron in its immediate neighborhood, whether used on direct or alternating current circuits, renders it impracticable as a switchboard instrument for alternating current circuits.

As an ammeter, it cannot be successfully employed for measurements above .5 ampere, due to the difficulty of providing perfectly flexible contacts capable of carrying large currents. When you attempt to convey a current into a moving coil beyond the carrying capacity of a flexible conducting spring, recourse must be had to mercury contacts, and a mercury contact should never be employed in a portable or enclosed type instrument. In the dynamometer instrument great care must be taken to have the moving coil as light as possible; and to render the instrument aperiodic, or dead-beat, an aluminum air vane, moving in a partially enclosed chamber, must be employed. Manually operated brakes acting on the delicate moving system should be avoided, as their continued use results in a serious derangement of the moving parts.

[To be Continued.]

## Exports of American Coal.

*Iron Age* says that the coal situation in Europe, which is evidently one of no little anxiety to the industrial statisticians, is made the basis of somewhat extravagant predictions on the part of dealers in this country of a great, immediate and rapidly increasing exportation of American coal. That our output, especially of bituminous coal, could be increased, will be admitted; but between the pit mouth and the foreign consumer there is literally "a great gulf fixed," which cannot be bridged or spanned quickly enough to meet any present or immediately prospective exigency of the foreign coal markets, so that any sudden and wonderful expansion of the coal exports of the United States may be regarded as improbable, if not impossible.

Probably the least difficult element of the problem of a great coal export from the United States is to mine the coal, but the preparations for this will consume a good deal of time and involve heavy investments of capital. The capital can be had easily enough, if it can be shown that the business is a permanent one and likely to pay a satisfactory profit. This might be difficult. The present scarcity and high price of coal in Europe are due chiefly to temporary causes. The restoration of peace in Africa and China and a relaxation of the present tension of industrial activity, especially in the iron and steel trades, would probably relieve any anxiety as to the coal supply of Europe and make our ability to market considerable quantities of coal dependent upon the price at which it was offered. There is also enough uncertainty as to the peace of Europe to make the conservative capitalist discreet in the matter of investments to supply the European coal demand. Coal is in the highest degree contraband of war, and should the threatened partition of China set the great Powers quarreling, and give France, in alliance with Russia, a chance to move against England and Germany, the transoceanic coal trade would be very seriously interrupted.

But with such a mining development as those who are anxious to handle coal for export are urging, the question of getting the coal to the seaboard remains to be answered. It is now difficult to procure cars enough for the present demands of coal transportation. They could, of course, be built, but the money needed to provide them would not be easily raised under present conditions. If, however, we had plenty of coal cars, we should have to build additional railroads to tidewater. The capacity of the roads leading to the Atlantic ports suitable for extensive coal shipments is pretty well congested as it is, and those which could materially increase their eastward movement of coal tonnage lack adequate terminal facilities and could not economically transfer any considerable quantity of coal from cars to ships. Those having such terminal facilities could not easily, quickly or cheaply increase them, and are quite sure not to consider doing so until the mileage of tracks and the supply of cars and engines needed to bring the coal to tidewater is assured. Coal docks on deep water are very expensive constructions. They will not be built until a constant and profitable use for them is shown, and without them the amount of coal exported will depend upon the amount which can be spared from the quantity that now reaches tidewater.

If, however, new sources of supply were developed, the cars and engines built, the additional tracks and necessary sidings laid, and the terminal facilities provided, where shall we find the fleet of ships to carry abroad as much coal as the statistical estimates show is needed to meet the European deficiency? They are not afloat at the present time.

The business of carrying coal could be made profitable to tramp steamers and other casual vessels only on the assurance of return cargoes, and there is not enough merchandise to be brought back to warrant vessel owners in engaging extensively in this business. Coal would not bear a rate of ocean freight high enough to make it pay to return the vessels in ballast. To meet this difficulty the dealers who are scheming for an extensive export trade in coal are agitating for the admission of foreign built ships to American registry, but it is not clear how this would help the matter any. There is not at present much tonnage suitable for coal carriage which could be picked up in Europe at low prices; and if such vessels cost nothing, it is doubtful if it would pay to run them empty one way to carry coal the other way. Coal is not yet dear enough in Europe to warrant this, and will not probably be dear enough for the next quarter of a century to make its carriage profitable to vessels which cannot anywhere secure return cargoes. What shall be imported to furnish such cargoes?

There is reason to believe that within the next few years a considerable and sustained increase will take place in the coal exports of the United States, but it cannot be immediate, nor is it likely for some time to figure prominently in our international trade balance. From many points of view this is fortunate. Coal is not like wheat or corn. Great as our natural resources undoubtedly are, they are not self replenishing. We have only so much coal, at best, and the obstacles in the way of exhausting our mines to stimulate and sustain the industries of other nations are happily a check upon present enterprise to the disadvantage of future generations. We have no more coal than we shall need, sooner or later, and there is no reason to regret that the way is not open for a great coal export at low prices. Exports of manufactures pay better, and will do vastly more to build up the national prosperity.

## ITEMS OF INTEREST FROM VARIOUS LOCALITIES.

PAPERS announcing the incorporation of the Whitestone (Long Island) Gas Company have been filed by Messrs. Charles B. Kudwig, Jno. F. Engle and H. L. Snyder. The capital stock is said to be $10,000. Whitestone is a post village of Queens county, N. Y., and is located on Long Island Sound at a point about 12 miles north and east of Brooklyn. It has several manufactories, and its population is not far from 4,500.

WE understand that Messrs. Dean & Shibley, a well-known banking firm of Napanee, Ontario, are negotiating for the purchase of the plants of the Belleville (Ont.) Gas Company and the Belleville Street Railway Company with a view to operating the same under one management.

THE properties of the Mount Sterling (Ky.) Gas Light Company have been purchased by the Montgomery Water Works Company.

THE firm of M. H. Treadwell & Co., composed of Messrs. Munson H. Treadwell and John H. Killinger, has been dissolved by mutual consent; either partner will sign in liquidation. The good will of the partnership has been transferred to the corporation of M. H. Treadwell & Co., which concern will continue the business of the partnership. Mr. Horace N. Dougherty, formerly of the Logan Iron Works, has been elected Vice-President of the corporation and will devote all of his time to its interests.

THE following is a reprint of the official selling schedule of the Oakland (Cal.) Gas, Light and Heat Company: Gas for illuminating purposes, $1.50 per 1,000 cubic feet; gas for fuel, where stove or other apparatus is connected with iron pipe, separate from light fixtures, $1.25 per 1,000 cubic feet.

Electric current for light, 24 hour service, by meter, 10 cents per 1,000 watts. Minimum bill per month, $1. Electric current for power, 24 hour service, by meter, 10 cents per 1,000 watts. Minimum bill per horse power per month, $1. All electric meter bills subject to following discounts for quantity, if paid within 5 days of date of bill:

For a consumption per month of—

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Over | 200,000 | watts | and | under | 400,000, | 5 | per cent., | making | rate | 9½ | cents. |
| " | 400,000 | " | " | " | 600,000, | 10 | " | " | " | 9 | " |
| " | 600,000 | " | " | " | 800,000, | 20 | " | " | " | 8 | " |
| " | 800,000 | " | " | " | 1,000,000, | 30 | " | " | " | 7 | " |
| Any | amount over | | | | 1,000,000 | watts, | 40 | " | " | " | 6 | " |

Electric current for power, 500 volts, flat rate, $5 per horse power per month; electric glow lamps, 10 o'clock service, $1 per month, 16-candle power lamps; electric glow lamps, 10 o'clock service, $2 per month per 32-candle power lamp.

Electric arc lamps under 6 months' contract:

| | 10 O'clock Service. | 12 O'clock Service. |
|---|---|---|
| 4 lights or less, per week, each | $2.00 | $2.75 |
| 5 to 7 lights per week, each | 1.90 | 2.60 |
| 8 " 10 " " " " | 1.85 | 2.50 |
| 11 or more " " " " | 1.75 | 2.40 |

A SPECIAL meeting of the shareholders of the Pacific Gas Improvement Company will be held August 30th to consider a proposition to create an indebtedness of $1,250,000, to be secured by the issue of bonds on the present property and on any other property that "may be acquired by the expenditure of money received in that way."

THE Quincy (Ills.) Gas and Electric Company has gotten out a new and attractive form of bill for consumers' account.

THE American Bridge Company, which is composed of 24 of the leading concerns, hitherto operated independently, in that line of construction, has been successfully launched. Prominent in its affairs is

the Berlin Iron Bridge Company, which Company has had much to do with gas works construction, particularly in the instance of roofs and kindred building. In the organization of the American Bridge Company Mr. Charles M. Jarvis, of the Berlin Iron Bridge Company, was chosen a Director, and we are more than pleased to note that the operating department of the Company has also been put under his charge. His official title is "Vice-President in charge of operating." He is a clever, capable and trustworthy gentleman, and it may be taken for granted that the vast work of his new engagement will be attended to in the manner that made dealings with him in the Berlin Iron Bridge Company a satisfaction rather than a task.

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We are informed that the Consumers Gas Company, of Newburgh, N. Y., has been purchased by Mr. B. B. Odell and his associates, who have for some time controlled the fortunes of the Consolidated Gas, Electric Light, Heat and Power Company, of Newburgh. It is surmised that Mr. F. R. Bain, of Poughkeepsie, will be elected President of the Company, and that Mr. C. L. Waring will be chosen Treasurer. The electricians had to get the gas company to secure themselves from continuing losses on operating account.

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At the annual meeting of the Burlington (Vt.) Gas Light Company the Directors elected were: B. B. Swathy, F. H. Wells, A. G. Peirce, M. A. Woodbury and R. G. Severson.

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A correspondent in Oakland, Cal., forwards the following under date of July 3d: "In reference to the reported absorption of the Equitable Gas Company, of Oakland, by the Oakland Gas, Light and Heat Company, William J. Dingee, President of the former Company, makes the following statement:

"'We owed $25,000 to the Oakland Savings Bank and $30,000 on mortgage to the Southern Pacific Company. Furthermore, we found that the service of gas was going to be a very expensive thing for two reasons: First, we had not met with the success we anticipated with the Welsbach lights, because the people asked for an open tip light, and, secondly, because we found that to serve the people of Oakland and Alameda the territory to be covered was vast. The old Company had laid its pipes gradually and was established. We would have been obliged very often to lay a stretch of pipe in neighborhoods where there were only two or three people to the block. The Hall system of manufacture would not do, and a water gas plant was essential. This meant an outlay of anywhere from $75,000 to $100,000, and the problem before the Directors was whether it was wise to raise this money in view of the uncertainty of successful competition. The old Company only makes about half a million cubic feet a day, and if we got all the business, which we could not expect, the profits would be small. Then the chance to sell out came. We cut the assessment of $1 a share to 20 cents, so as to pay off the Oakland Savings Bank, and now if a sale be made at once we can all get $1.10 a share for our stock. That is about all there is to say about the deal; in short, we saw that the best thing we could possibly do was to sell out.'"

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At the annual meeting of the shareholders in the Consolidated Gas Company, of Baltimore, Md., which session will be held to-day, the opposition ticket for Directors, which has been arranged by Mr. Charles H. Dickey, will be as follows: Wm. A. Read, Anthony N. Brady and F. S. Hastings, of New York; Wm. Powell Wilson, of Boston; and Chas. H. Dickey, S. Davies Warfield, Chas. A. Webb, W. H. Grafflin, Thornton Rollins, and A. J. Shriver, of Baltimore.

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The proprietors of the Warsaw (N. Y.) Gas and Electric Company, have notified their patrons that because of the advance in the prices of coal, oil and other materials entering into the manufacture of gas and electricity, they are obliged to increase the selling rates for gas and electric lights. The schedule is appended:

| Consumption, Per Month. | Rate Per 1,000. |
|---|---|
| 3,000 cubic feet or under | $2.30 |
| 3,000 " " to 5,000 cubic feet | 2.10 |
| 5,000 " " and over | 1.90 |

Gas used on fuel and power account is to be billed at $1.90 per 1,000. The charges for electric current are: Up to 10,000 watts per month, 17 cents per 1,000; 10,000 to 25,000 watts, 16 cents per 1,000; 100,000 watts and over, 12 cents per 1,000. All flat rates are advanced 15 per cent.

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Messrs. D. F. Foster and Charles E. Dawes have purchased a controlling interest in the Waukegan (Ills.) Gas Company.

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The proprietors of the Lawrence (Mass.) Gas Company, after a conference with the local authorities, have decided to reduce the selling rate to $1 per 1,000 cubic feet, the rate to become operative August 1st.

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The Worcester (Mass.) Gas Light Company, in addition to its regular quarterly dividend of 2 per cent., is disbursing an extra cash dividend of 10 per cent. This extra payment represents accumulated moneys for several years.

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The opposition Company for Binghamton, N. Y., which is under the fostering care of Messrs. Robert H. Rose, Thos. B. Crary, Cornelius H. Ackerman, Willis H. Gaylord, George H. Barlow and J. M. Kilmer, is not likely to materialize.

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Mayor Weaver, of Louisville, is in favor of selling the stock in the Louisville Gas Company owned by the city. If memory may be counted upon, our belief is that the city owns $925,000 of stock in the Louisville Company. At the annual meeting of the Louisville Gas Company the 5 Directors elected on the Company's account were: H. V. Loving, Udolpho Snead, John Stites, K. W. Smith and John B. Hundley—the latter succeeds Mr. D. X. Murphy.

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The Essex and Hudson Gas Company, of Newark, N. J., proposes to extend its mains to and through the borough of North Arlington.

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In the competition instituted by *Municipal Engineering*, "for the best and most complete set of forms for use in conducting the business of a gas lighting plant suited to cities under 100,000 population," the prize was awarded to Mr. James R. Shutz, of the Trenton (N. J.) Gas and Electric Company.

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The Borough Council of Cambridge, Pa., has granted a franchise to J. T. and F. R. Connolly, of Bradford, Pa., for the maintaining of a gas works.

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The *Scientific American* says that M. Dufour gives an account to the Academie des Sciences of a series of experiments which he has made regarding the use of quartz for thermometers and other instruments. As quartz may be softened in the oxy-hydrogen blowpipe, and may there be worked like glass, he was able to make tubes of quartz, and afterward thermometers of the same material. Quartz may be applied to the construction of various apparatus, and may be of service; first, where a transparent substance and one not easily melted is required; secondly, where a transparent envelop of definite composition, but slightly affected by hygrometric conditions is called for. The first of these conditions is realized by the quartz thermometer, which consists of a reservoir of quartz and a tube of the same material. As for the liquid, it must be a body which it is easy to obtain in the pure state, and which melts at a relatively low temperature, giving off no vapors up to a red heat; moreover it should contract on solidifying. He finds that tin answers perfectly these conditions, and has constructed a thermometer, using tin as a metal, which reads from 240° to 580° C. As quartz softens only at 1,000° to 1,200°, a thermometer may he made which reads up to 900°; it can be graduated by utilizing the boiling points of mercury and sulphur and the level of the tin is well defined in the two cases. To go higher, the boiling points of cadmium and zinc may be taken. The thermometer was filled with melted tin and as perfect a vacuum as possible was obtained, after which the end was closed by the blowpipe. The last bubbles of air were taken out by melting the tin, while giving it repeated shocks. If the tin has traces of oxide, this adheres to the sides of the reservoir and remains fixed. The upper surface is always brilliant, and has the same appearance as mercury. The reservoir should have rather thick walls to avoid rupture when the metal cools. M. Dufour hopes that quartz may supersede glass in the construction of vacuum tubes for spectroscope work. He observes that when a glass rod is melted in the oxy-hydrogen blowpipe flame there is a disengagement of gas, which is due either to a reaction which is completed at this high temperature, or to the evolution of gases which have been previously dissolved in the glass. On the other hand, quartz melts quietly and no gas is given off. In experiments with spectroscopic tubes, difficulties are met with which seem to be due to gases given off by the glass; it may be supposed that the use of quartz will remedy these, and as it is a body of definite composition, not oxidized, reduced with difficulty, but little hygrometric and dielectric, it will be seen that it could be used to advantage for making spectroscope tubes. M. Dufour is now making a hydrogen tube of quartz, and expects it to give a perfect spectrum; if so, he will utilize it in establishing a theory of vacuum tube phenomena.

## The Market for Gas Securities.

The city gas share market is very quiet, the trading for the week having been more than usually restricted, even for mid-July. Underlying the dullness, however, is a dogged assertion of strength that speaks well for the events which are to follow the special meeting of the Consolidated Company's shareholders set for next Monday. To-day (Friday) Consolidated closed at 174½ to 175½, and considerable inquiry was made near the closing on borrowing account.

Mutual as to the little that is left of it outside of the dominating circle, is being constantly inquired for nominally at 310 bid.

Holders of New Amsterdams who did not assent to the terms of the debenture conversion or transfer will be permitted to come in later on equal terms with those who did, unless all signs fail.

Standards are nominal as to quotations. Next week it is fair to presume that positive signs of the beginning of the end in the final consolidation will be revealed by Mr. Stillman and his co-workers, and unless we are all wrong the value of Consolidated will be much higher by the 1st prox. than it is now.

Brooklyn Union keeps up with the procession pretty well, as does Peoples, of Chicago. The Dickey contingent is quite confident of success in the matter of their attempt to change the management of the Baltimore Company; but, whether successful or not, Mr. Dickey is entitled to credit from the Company's ordinary shareholders for the impetus that his acts have given to the present management. We hope that he will win. The gas bond market continues strong.

## Gas Stocks.

**Quotations by George W. Close, Broker and Dealer in Gas Stocks.**

16 WALL STREET, NEW YORK CITY.

JULY 16.

☞ All communications will receive particular attention.

☞ The following quotations are based on the par value of $100 per share.

| *N. Y. City Companies.* | *Capital.* | *Par.* | *Bid.* | *Asked.* |
|---|---|---|---|---|
| Consolidated | $4,595,200 | 100 | 174½ | 175½ |
| Central Union, Bonds, 5's. | 3,000,000 | 1,000 | 103¼ | 105 |
| Equitable Bonds, 6's | 1,000,000 | 1,000 | 105 | .. |
| " 1st Con. 5's | 2,300,000 | 1,000 | 115 | 118 |
| Metropolitan Bonds | 658,000 | .. | 108 | 112 |
| Mutual | 3,500,000 | 100 | 305 | 320 |
| " Bonds | 1,500,000 | 1,000 | 100 | 102 |
| Municipal Bonds | 750,000 | .. | .. | .. |
| New Amsterdam Gas Co. .. | | | | |
| Bonds, 5's | 11,000,000 | 1,000 | 103 | 103¼ |
| Northern Union, Bonds, 5's. | 1,250,000 | 1,000 | 95 | 97 |
| New York and East River.. | | | | |
| Bonds 1st 5's | 3,500,000 | 1,000 | 109 | 111 |
| " 1st Con. 5's | 1,500,000 | .. | 115 | .. |
| Richmond Co., S. I. | 348,650 | 50 | 70 | .. |
| " Bonds | 100,000 | 1,000 | .. | .. |
| Standard | 5,000,000 | 100 | 121 | 125 |
| Preferred | 5,000,000 | 100 | 141 | 145 |
| Bonds, 1st Mortgage, 5's | 1,500,000 | 1,000 | 110 | 114 |
| Yonkers | 299,650 | 500 | 130 | .. |
| *Out-of-Town Companies.* | | | | |
| Brooklyn Union | 15,000,000 | 100 | 165 | . |
| " " Bonds (5's) | 15 000,000 | 1,000 | 118 | 119 |
| Bay State | 50,000,000 | 50 | 1¼ | 1¾ |
| " Income Bonds | 2,000,000 | 1,000 | .. | 75 |
| Binghamton Gas Works | 450,000 | 100 | . | 35 |
| " 1st Mtg. 5's | 475,000 | 1,000 | 90½ | 92½ |
| Boston United Gas Co.— | | | | |
| 1st Series S. F. Trust | 7,000,000 | 1,000 | 82 | 85 |
| 2d " " " | 3,000,000 | 1,000 | 47½ | 50 |
| Buffalo City Gas Co. | 5,500,000 | 100 | 4 | 5¼ |
| " " Bonds, 5's | 5,250,000 | 1,000 | 64 | 67 |
| Central, San Francisco | 2,000,000 | .. | 106 | 108 |
| Chicago Gas Co. Guaranteed Gold Bonds | 7,650,000 | 1,000 | 104 | 104¼ |
| Columbus (O.) Gas Co., 1st Mortgage Bonds | 1,207,000 | 1,000 | 106 | 107 |
| Columbus (O.) Gas Lt. & Heating Co | 1,082,720 | 100 | 60 | 65 |
| Preferred | 3,026,500 | 100 | 84 | 86 |
| Consumers, Jersey City Bonds | 600,000 | 1,000 | 102 | 105 |
| Cincinnati G. & C. Co. | 8,500,000 | 100 | 200¾ | 201 |
| Consumers, Toronto | 1,700,000 | 50 | 230 | 235 |
| Capital, Sacramento | 500,000 | 50 | .. | 35 |
| Bonds (6's) | 150,000 | 1,000 | .. | .. |
| Consolidated, Baltimore | 11,000,000 | 100 | 57¼ | 58 |
| Mortgage, 6's | 3,800,000 | .. | .. | 118 |
| Chesapeake, 1st 6's | 1,000,000 | .. | .. | .. |
| Equitable, 1st 6's | 910,000 | .. | .. | .. |
| Consolidated, 1st 5's | 1,490 000 | .. | .. | 112 |
| Consolidated Gas Co. of N.J. | 1,000,000 | 100 | 12½ | 15 |
| " Con. Mtg. 5's | 380,000 | 1,000 | 82 | 86 |
| Consolidated G. & E. Co.'s, Little Falls, N.Y. | 90,000 | 100 | .. | 100 |
| Bonds | 75,000 | .. | .. | 100 |
| Detroit City Gas Co. | 4,560,000 | 50 | 95¾ | 96 |
| " Prior Lien 5's | 4,598,000 | 1,000 | 99½ | 100 |
| Detroit Gas Co., 5's | 386,000 | 1,000 | 100 | 101 |
| " Inc. 5's | 16,000 | 100 | 100½ | 101 |
| Equitable Gas & Fuel Co., Chicago, Bonds | 2,000,000 | 1,000 | .. | 101 |
| Essex and Hudson Gas Co. | 5,500,000 | .. | 35 | 40 |
| Fort Wayne | 2,000,000 | .. | 35 | 41 |
| " Bonds | 2,000,000 | .. | 60 | 64 |
| Grand Rapids Gas Lt. Co.. | 1,000,000 | 50 | .. | .. |
| " 1st Mtg. 5's | 1,125,000 | 1,000 | .. | .. |
| Hartford | 750,000 | 25 | .. | 220 |
| Hudson County Gas Co., of New Jersey | 10,500,000 | .. | 25 | .. |
| " Bonds, 5's | 10,500,000 | .. | 101 | 103 |
| Indianapolis | 2,000,000 | .. | 90 | 100 |
| " Bonds, 6's | 2 650,000 | .. | 100 | 104 |
| Jackson Gas Co. | 250,000 | 50 | 72 | 73 |
| " 1st Mtg. 5's | 250,000 | 1,000 | 101 | 102½ |
| Kansas City Gas Light Co., of Missouri | 5,000,000 | 100 | .. | 36 |
| Bonds, 1st 5's | 3,822,000 | 1,000 | 101¾ | 103 |
| Laclede, St. Louis | 7,500,000 | 100 | 75 | 75¼ |
| Preferred | 2,500,000 | 100 | 99 | 100 |
| Bonds | 10,000,000 | 1,000 | 110 | 110½ |
| Lafayette Gas Co., Ind. | 1,000,000 | 100 | 40 | 45 |
| Bonds | 1,000,000 | 1,000 | 60 | 65 |
| Louisville | 2,570,000 | 50 | 106 | |
| Madison Gas & Elec. Co. | 400,000 | 100 | 75 | 80 |
| " 1st Mtg. 6's | 350,000 | 1,000 | 102½ | 108 |
| Montreal, Canada | 2,000,000 | 100 | 182 | 184½ |
| Newark, N. J., Con. Gas Co | 6,000,000 | .. | .. | 55 |
| Bonds, 6's | 4,600,000 | .. | .. | 103 |
| New Haven | 1,000,000 | 25 | 280 | 300 |
| Nashville Gas Lt. Co. | 1,000,000 | 50 | 110 | .. |
| Oakland, Cal. | 2,000,000 | .. | 46 | 47 |
| " Bonds | 750,000 | .. | .. | .. |
| Peoples G. L. & Coke Co., of Chicago | 25,000,000 | 100 | 98¼ | 98¾ |
| Peoples Gas Lt. & Coke Co., Chicago, 1st Mortgage | 20,100,000 | 1,000 | 111⅝ | 111½x |
| 2d " | 2,500,000 | 1,000 | 104 | 105 |
| Rochester Gas & Elec. Co. | 2,150,000 | 50 | 88 | .. |
| Preferred | 2,150,000 | 50 | 118 | .. |
| Consolidated 5's | 2,000,000 | .. | 87½ | 90 |
| San Francisco, Cal. | 10,000,000 | 100 | 47¼ | 47½ |
| St. Paul Gas Light Co. | 1,500,000 | 100 | 57¼ | 58½ |
| 1st Mortgage 6's | 650,000 | 1,000 | 82 | 85 |
| Extension, 6's | 600,000 | 1,000 | .. | .. |
| General Mortgage, 5's | 2,428,000 | 1,000 | 89 | 90½ |
| St. Joseph Gas Co. | 1,000,000 | 100 | 42 | 44 |
| " 1st Mtg. 5's | 750,000 | 1,000 | 98½ | 98 |
| Syracuse, N. Y. | 1,750,000 | 100 | 14 | 15 |
| Bonds | 1,612 000 | 1,000 | 86½ | 93 |
| Washington, D. C | 2,600,000 | 20 | 270 | 271 |
| First mortgage 6's | 600,000 | .. | .. | .. |
| Western, Milwaukee | 4,000,000 | 100 | 95 | 98 |
| Bonds, 5's | 3,830,500 | . | 104 | 106 |
| Wilmington, Del. | 600,000 | 50 | 200 | 210 |

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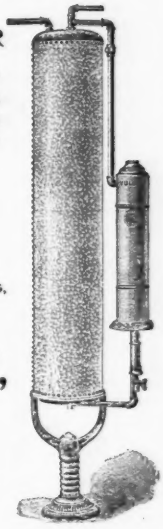

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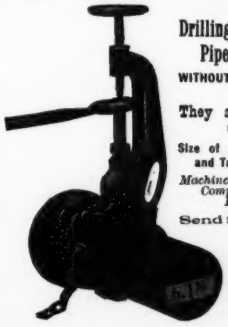

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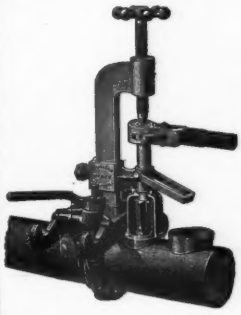

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| Kingston, Pa. | 125,000 |
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| Buffalo, N. Y. | 2,000,000 |
| Winnipeg, Man. | 500,000 |
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| Tonbridge, England | 300,000 |
| Stretford, England | 500,000 |
| Oldbury, England | 300,000 |
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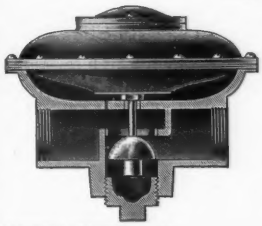

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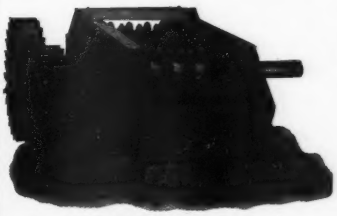

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Tarrytown, N.Y., 3 orders.
Ft. Henry, N. Y.
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Hollidaysburg, Pa.
Waterville, N. Y.
Huntington, L. I.
Lexington, Mo.
Mendota, Ill.
Circleville, O.
Joplin, Mo.
Ashville, N. C.
Youngstown, O.
Kingston & Rondout, N. Y.

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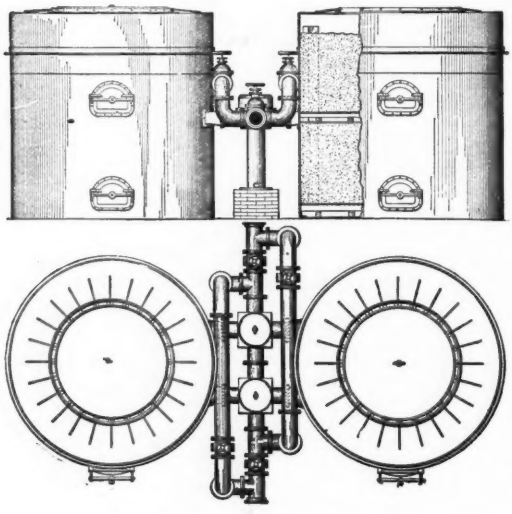

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Covered by Five U.S. Patents.

In operation, revivification of the oxide is effected by repeated reversals of the direction of the flow of the gas through the beds (in the two boxes used under this system there are eight different routes for the gas to take) whereby the purified gas is made to revive the oxide in parts of the apparatus while the foul gas is fouling it in others.

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## For the Year 1899.

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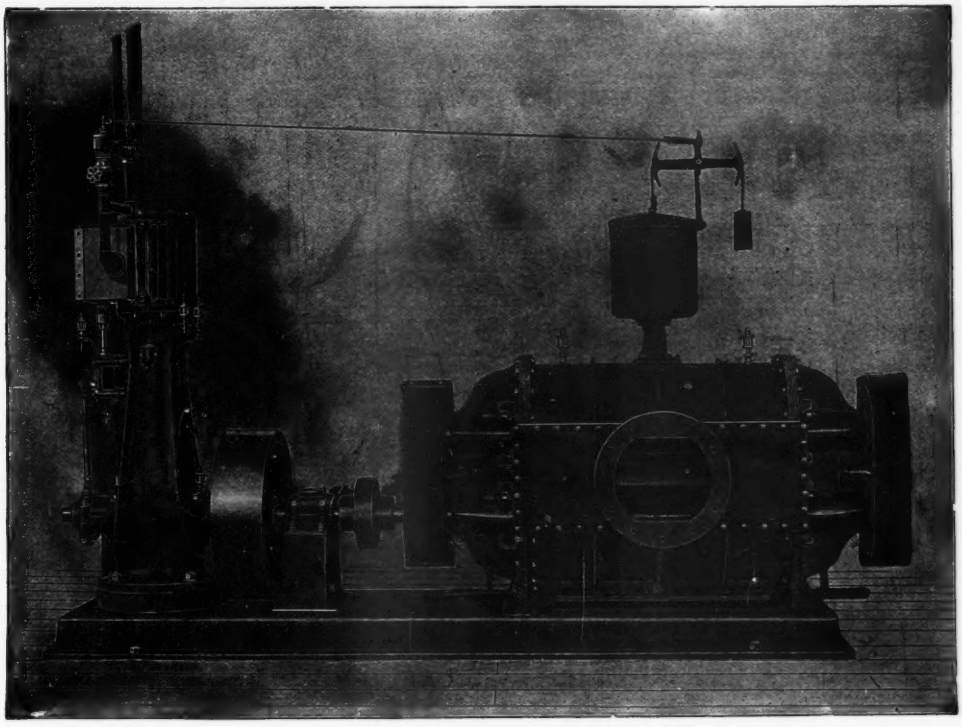

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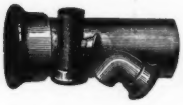

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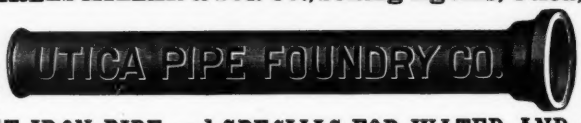


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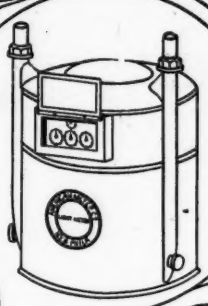

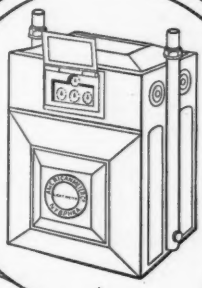

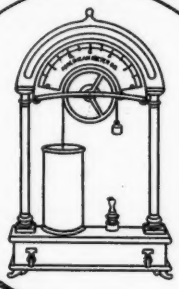

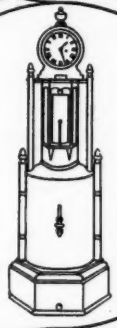

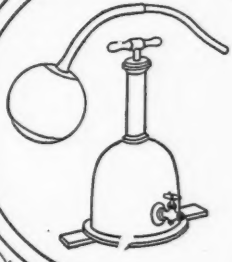

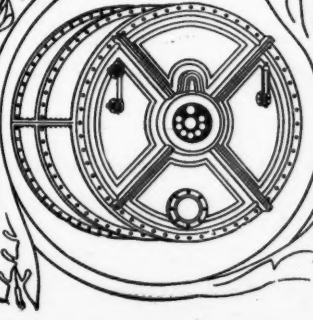

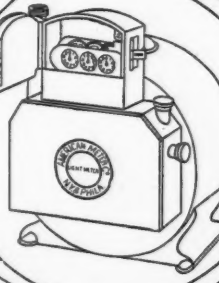

## PUBLIC LIGHTING TABLE.

### AUGUST, 1900.

| Day of Week. | Date. | Table No. 1. FOLLOWING THE MOON. Light. | Extinguish. | Table No. 2. NEW YORK CITY. ALL NIGHT LIGHTING. Light. | Extinguish. |
|---|---|---|---|---|---|
| | | | | P.M. | A.M. |
| Wed. | 1 | 8.50 PM | 4.00 AM | 7.10 | 3.30 |
| Thu. | 2 | 9.20 | 4.00 | 7.10 | 3.30 |
| Fri. | 3 | 10.00 FQ | 4.00 | 7.10 | 3.30 |
| Sat. | 4 | 10.40 | 4.00 | 7.10 | 3.30 |
| Sun. | 5 | 11.30 | 4.10 | 7.10 | 3.30 |
| Mon. | 6 | 12.20 AM | 4.10 | 7.10 | 3.45 |
| Tue. | 7 | 1.30 | 4.10 | 7.10 | 3.45 |
| Wed. | 8 | 2.30 | 4.10 | 7.10 | 3.45 |
| Thu. | 9 | No L. | No L. | 7.10 | 3.45 |
| Fri. | 10 | No L. FM | No L. | 7.10 | 3.45 |
| Sat. | 11 | No L. | No L. | 7.10 | 3.45 |
| Sun. | 12 | 7.30 PM | 8.50 PM | 7.10 | 3.45 |
| Mon. | 13 | 7.30 | 9.20 | 6.55 | 4.00 |
| Tue. | 14 | 7.30 | 10.00 | 6.55 | 4.00 |
| Wed. | 15 | 7.30 | 10.30 | 6.55 | 4.00 |
| Thu. | 16 | 7.30 LQ | 11.20 | 6.55 | 4.00 |
| Fri. | 17 | 7.30 | 12.00 | 6.55 | 4.00 |
| Sat. | 18 | 7.30 | 12.50 AM | 6.55 | 4.00 |
| Sun. | 19 | 7.20 | 1.50 | 6.55 | 4.00 |
| Mon. | 20 | 7.20 | 2.50 | 6.45 | 4.10 |
| Tue. | 21 | 7.20 | 4.20 | 6.45 | 4.10 |
| Wed. | 22 | 7.20 | 4.20 | 6.45 | 4.10 |
| Thu. | 23 | 7.20 | 4.20 | 6.45 | 4.10 |
| Fri. | 24 | 7.20 NM | 4.20 | 6.45 | 4.10 |
| Sat. | 25 | 7.20 | 4.20 | 6.45 | 4.10 |
| Sun. | 26 | 7.10 | 4.20 | 6.45 | 4.10 |
| Mon. | 27 | 7.10 | 4.20 | 6.30 | 4.20 |
| Tue. | 28 | 7.10 | 4.20 | 6.30 | 4.20 |
| Wed. | 29 | 7.20 | 4.20 | 6.30 | 4.20 |
| Thu. | 30 | 8.00 | 4.20 | 6.30 | 4.20 |
| Fri. | 31 | 8.40 | 4.20 | 6.30 | 4.20 |

### TOTAL HOURS LIGHTING DURING 1900.

| By Table No. 1. | Hrs.Min. | By Table No. 2. | Hrs.Min. |
|---|---|---|---|
| January | 230.50 | January | 423.20 |
| February | 175.40 | February | 355.25 |
| March | 189.00 | March | 355.35 |
| April | 160.30 | April | 298.50 |
| May | 150.40 | May | 264.50 |
| June | 137.00 | June | 234.25 |
| July | 152.00 | July | 243.45 |
| August | 171.50 | August | 280.25 |
| September | 187.20 | September | 321.15 |
| October | 213.10 | October | 374.30 |
| November | 221.50 | November | 401.40 |
| December | 231.50 | December | 433.45 |
| Total, yr. | 2321.40 | Total, yr. | 3987.45 |

NEW YORK, 33 Nassau St. PHILADELPHIA, Broad and Arch Sts. CHICAGO, 54 Lake St.

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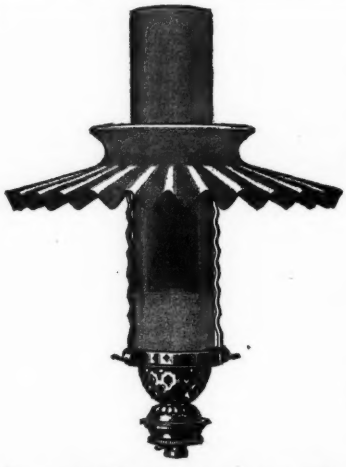

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THE STANDARD JUNIOR,

THE STANDARD DOUBLE SUPERHEATER,

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Total Sets Installed to January 1, 1900, - - - - - - - - 327

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FOR IMPROVEMENTS OR
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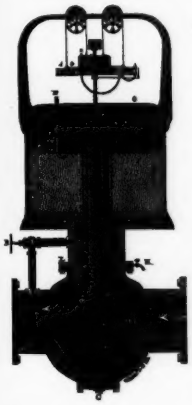

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"Iron Sponge" and Natural Oxide
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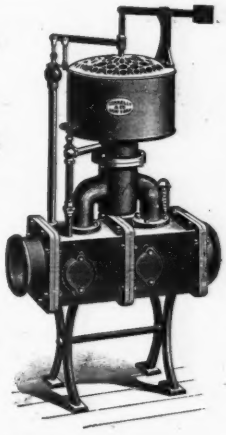
EXHAUSTERS, ETC.



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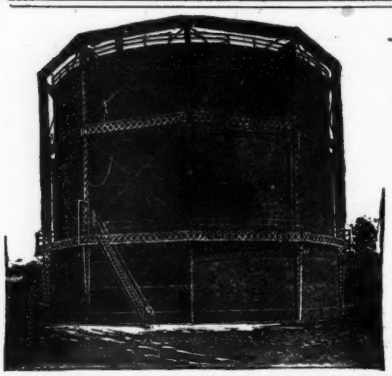

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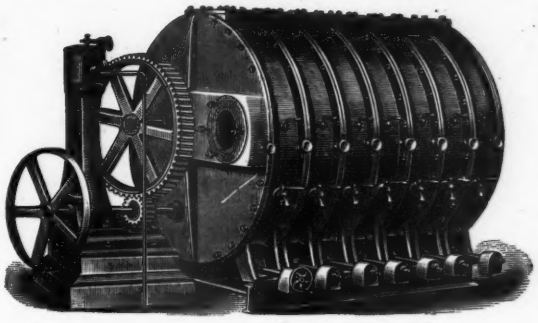

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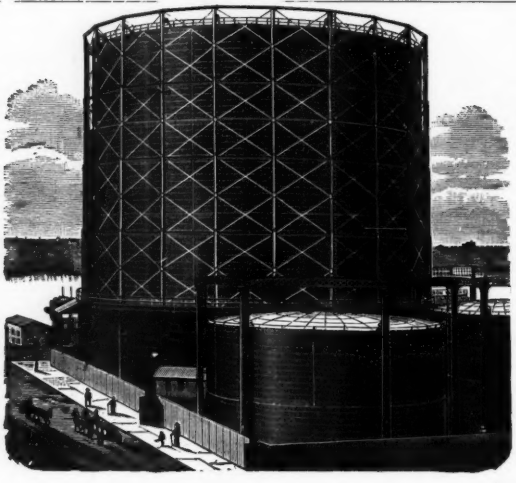

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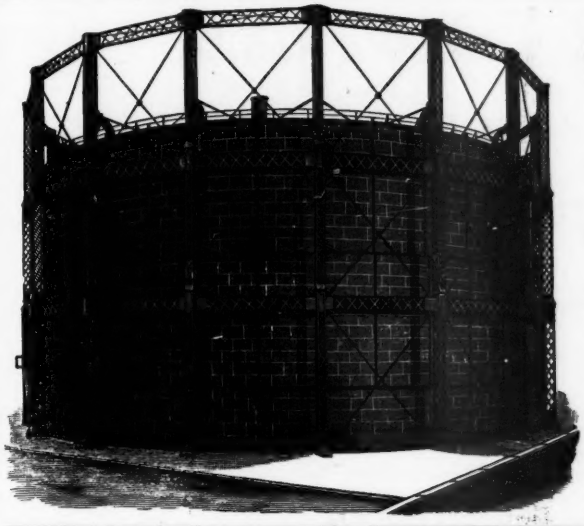

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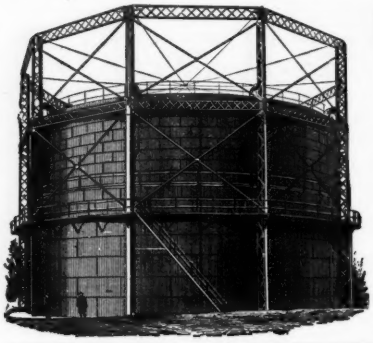

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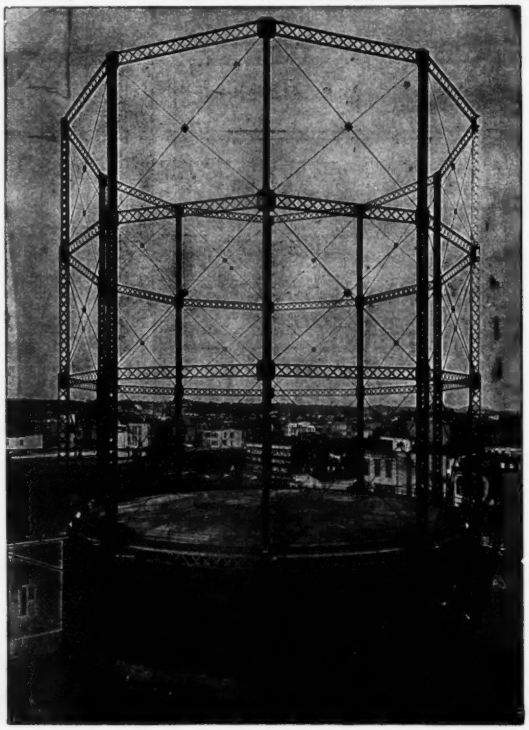

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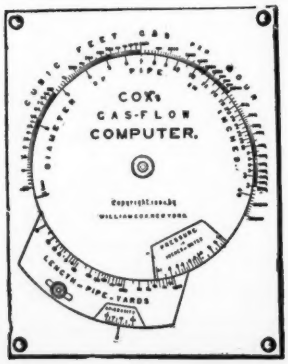


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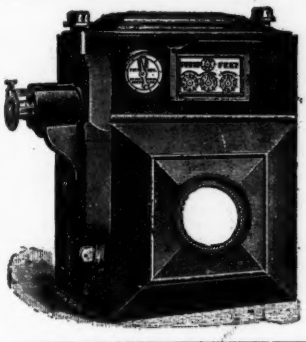

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The BUHL METERS are as good Meters as you can get.

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